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Copper Removal at the Gardner Wastewater Treatment Facility

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A Major Qualifying Project

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by

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Abstract

In the recent past, the Gardner Wastewater Treatment Facility has not consistently met permitted limits for copper discharge. The goal of this project was to gather qualitative information on the copper in the wastewater flow, such as total & dissolved copper levels, particle sizes, & possible copper sources. Testing was then conducted to determine possible treatment options. It was concluded that removing sources of contamination and chemical precipitation would provide the most effluent copper reduction.

Acknowledgements

A special thanks to Professor James O'Shaughnessy and lab manager Don Pellegrino of WPI's Department of Civil & Environmental Engineering and Professor Chickery Kasouf of WPI's School of Business for their guidance and assistance throughout the course of this project. We would also like to thank Mr. Dane Arnold, Gardner Director of Public Works, Mr. Robert Sims of the Maguire Group, and Tracy Earnest and the staff at the Gardner WWTF for their continued assistance and accommodation during this project.

Executive Summary

The United States Environmental Protection Agency (EPA) is concerned with high concentrations of heavy metals such as copper in any water body because it will lead to numerous environmental issues affecting aquatic and human lives that depend on the waterway. High levels of copper in water can be deadly for many different aquatic organisms, thus altering the natural ecosystems living in streams, rivers and lakes. The Gardner Wastewater Treatment Facility (WWTF), located in East Templeton, Massachusetts and operated by the city of Gardner, is experiencing problems meeting their maximum permitted copper levels set forth by the EPA. The goal of this Major Qualifying Project is to investigate possible copper removal techniques within the WWTF, identify copper contamination within the city's sewer system and propose recommendations for additional copper treatment and management solutions to be further studied for implementation by the city of Gardner.

The EPA is tasked with protecting human health and the environment by determining and enforcing regulations. The EPA enforces various environmental laws through fines and sanctions, along with other methods. To ensure that all Americans have access to safe drinking water, the EPA has set standards for public sewer systems in the United States. The vast majority of these public sewer systems are regulated through the National Pollutant Discharge Elimination System (NPDES) permits. The NPDES program, developed to protect the water quality of natural water bodies with the US, involves many steps, beginning with the submission of an application by the discharging agency or facility and ending with the development and writing of discharge limits specific to the applicant facility. The NPDES permit sets effluent limitations not only based on the industry, technology and pollutant data but also aquatic life and recreation in the body of water in which the effluent is discharged. Once the limits are set, the discharging facility is responsible for meeting the limits and must take steps to ensure this.

The NPDES permit also allows for certain limits to be altered or relaxed if the treatment facility presents a case for it to the permitting agency. For example, when it became clear that the Gardner WWTF could not meet stringent limits on copper discharge, a higher limit was temporarily introduced until a new limitation could be developed and put in place. Gardner's NPDES permit also allows the city to set limitations for users discharging into the city sewer system. Therefore, the city has developed local limits set forth in their sewer ordinance. These users must meet the Gardner's requirements or face penalties enforced by the city. Regardless of the discharge from these individual facilities the WWTF must still meet the required discharge limit at the plant.

In order to accomplish the goals set forth in this project, the team conducted numerous laboratory tests to identify copper removal within the plant and to investigate possible design solutions to provide for further copper removal. An extensive plant sampling routine was carried out to show existing copper removal within the Gardner WWTF. Samples were also tested from other area wastewater treatment facilities to show a copper removal trend. A filtration experiment was conducted by the team to identify any relationship between solid particle size and copper concentration in the wastewater. The hardness of the Otter River, which the Gardner WWTF discharges to, and the plant effluent were determined. Hardness is a measure of the levels of metals in the water, and has an effect

on the determination of discharge limits for copper. A precipitation experiment was also carried out by the team as a method for copper removal at the Gardner WWTF. In addition to the several laboratory experiments conducted by the team, a survey was prepared and distributed to industrial users within the city of Gardner in order to identify any users that may be discharging high levels of copper into the city sewer system.

The results of the testing of copper levels within the Gardner WWTF were as expected. The total copper level decreased linearly as it progressed through the plant's treatment stages. The plant influent had an average total copper value of 79.21 parts per billion (ppb), while the effluent had an average total copper value of 23.15 ppb. The majority of the copper entering the WWTF is particulate copper suspended in the water. Unlike the total copper levels, the dissolved copper levels did not reduce linearly in the plant filtering process. The final clarifier had higher dissolved copper levels in 5 of the 6 trials conducted. These higher values can be explained by the reactions taking place in the activated sludge tanks. The results show that dissolved copper is less of a problem and harder to filter than total copper, so total copper is the primary target for removal in the WWTF. The results from this experiment can be found below in Figure 1.

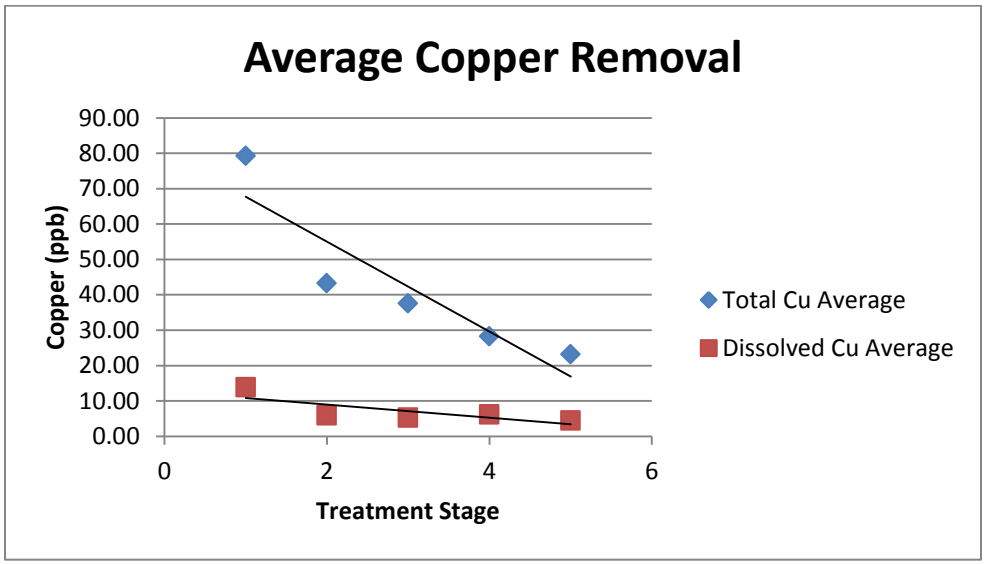

Figure 1: Average total & dissolved copper removal in the Gardner WWTF

After conducting filter testing using 4 filter sizes ranging from 0.45 µm to 10 µm, the particle sizes were deemed too small for efficient removal from Gardner's WWTF. The next focus of testing was to determine if the soluble copper could be precipitated into slurry, which could then be filtered. On a small-scale model with an exaggerated amount of dissolved copper, the results were positive. However, copper removal by precipitation is not as effective with lower concentrations, such as the copper level entering the Gardner WWTF. With almost all possible solutions exhausted, the potential for applying for a new permit from the EPA is another efficient way of obtaining copper values within their regulations.

Applying for a new permit would require hardness tests of both upstream (Otter River) and the plant effluent. The results of the hardness test concluded similar results to those obtained from the EPA.

After review of the results of the laboratory experiments the group conducted, it was decided to provide several recommendations to the city of Gardner for further investigation of copper removal at the WWTF. Possible plant upgrades include: the addition of a sand filtration unit, the addition of a reverse osmosis or ion exchange system and the addition of a reactor for copper precipitation from the wastewater. In addition to these solutions, land application can be explored as an alternative to discharging into the Otter River. The results of the industrial survey should be reviewed and further investigation should be carried out if the results indicate high concentrations of copper in one area of the city. An option to remove any possible sewer flows high in copper concentration would be a sewer system separation. In this option, the city's industrial users would discharge to a separate system, and the wastewater from that system could be further treated and discharged separately. This project provides the city with several methods for copper removal in order to meet NPDES requirements and protect wildlife in the Otter River.

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Chapter 1: Introduction

Modern-day wastewater treatment facilities are required to eliminate and reduce many forms of toxins and pollutants in order to ensure for the environmental safety of American waterways. Until the twentieth century, advanced wastewater treatment and collection systems did not exist. With the discovery of waterborne pathogens such as cholera, and with advancement in treatment technologies, wastewater collection and treatment became more commonplace. Throughout the 1900s, the technology and methods of wastewater treatment continued advancement. Governments, media and the general population also became more aware and concerned with issues affecting the health of the environment. This led to regulation of wastewater treatment systems and specific legislation dealing with discharge limits.

Today in the US, the Environmental Protection Agency, through its NPDES permitting process, regulates all wastewater treatment systems, both industrial and municipal. The EPA has developed processes to set limits on a wide range of pollutants and nutrients that may be harmful to the environment in wastewater. Individual facilities often have different limits from one another, depending on the composition of the wastewater flow and the discharge waters. For example, plants discharging to salt water have stricter limits on nitrogen and those discharging to fresh water have more stringent limits on phosphorous.

One of the several metals regulated for discharge by the EPA at almost every wastewater treatment facility is copper. Copper is used in a variety of products and applications, and can be especially prevalent in water and wastewater systems. Copper is used for algae control in reservoirs, is also a common material in household plumbing, and is also used as a root killer in underground pipes. Due to the dramatic effect that high levels of copper can have on aquatic life, the EPA regularly sets strict discharge limitations for copper.

The city of Gardner, Massachusetts has not consistently met its permitted copper discharge limit in recent years. The EPA has issued administrative orders requiring the city to take action in ensuring its treatment facility can consistently meets these limitations. The city has undertaken steps already to reduce the copper in its wastewater flow. A new water treatment facility was recently built, an aggressive inflow and infiltration program was carried out, and a copper study was completed at the treatment plant. The city's latest effort to reduce copper concentrations includes this project.

This project aims to demonstrate existing copper removal within the Gardner Wastewater Treatment Facility, investigate possible sources of copper contamination within the city's sewer system, study methods of copper removal at the treatment facility, and conduct a management review of the treatment plant's operations. Numerous laboratory experiments were performed to achieve these goals. A survey was distributed to city industries, and a management analysis of the plant and its proposed upgrades was conducted. The findings from the research performed were then analyzed by the group, and recommendations were made for the city to conduct further research.

Chapter 2: Background

2.1 History of Wastewater Treatment

Wastewater treatment and wastewater collection have evolved to a very standardized and technologically advanced industry. For hundreds of years no treatment or sewage systems existed for wastewater, and said wastewater was dumped into streets and left to flow wherever the road took it. As one can imagine, this led to serious disease and terribly unsanitary and dangerous health conditions that caused deadly epidemics. As communities grew and more people came to live near one another, the need for better water quality was necessary. Without clean water, humans cannot be expected to survive very long. The need to supply safe water, remove wastewater, and to protect public health were main concerns that grew more important throughout generations. Therefore, understanding the causes of disease outbreaks such as cholera and dysentery led to the development of infrastructures and processes that could be implemented to prevent these health problems. Much research and advancement in the understanding of bacteria and waterborne diseases led to great strides and efforts in public sanitation. Once it was discovered that the lack of wastewater collection and treatment was the root cause to diseases such as typhoid fever, cholera, and dysentery, wastewater treatment and collection was taken much more seriously and steps toward disinfection progressed.

As long as humans have walked the earth, they have created waste. The issue of pure water supplies and wastewater did not become an issue until people began settling down and building cities. The earliest records of wastewater disposal go back approximately 5,000 years, to the city of Nippur, in Sumeria. This early sewerage system carried away wastes from the city's homes and palaces. Over 3,000 years later in the year A.D. 98, Sextus Julius Frontinus, the water commissioner of Rome noted, "I desire that nobody shall conduct away any excess water without having received my permission or that of my representatives." Frontinus was speaking of Rome's sewer system, which was designed primarily to handle storm runoff. He did not want Roman people discharging into his sewer because he recognized the need for cleaning and maintenance of the system. It is interesting to note, that although Nippur and Rome did in fact have sewers, there are only few known instances of direct connections being made to homes and palaces. The vast majority of homes did not have direct access to either city's sewer system.[1]

From the days of ancient Rome until the middle of the nineteenth century, no prominent progress was made in sewage systems. The city of Hamburg, Germany experienced a devastating fire that destroyed the old section of the city in 1842. City officials made the decision to rebuild the city to include modern ideas pertaining to sanitation. An English engineer, W. Lindley, was hired to design a collection system that incorporated many ideas still in use today. Unfortunately, it would take time for many to recognize that Lindley was ahead of his time and many of his ideas were not put into practice for quite a while.[2]

[1] Viessman, Jr., Hammer, Perez & Chadik, p. 2
[2] Ibid, p. 2

During the 1850's the first comprehensive sewage system was designed and implemented in Chicago by an engineer named Ellis Chesborough, who was also responsible for the design of Boston's water distribution system, in response to Chicago's public health crisis. Chesborough's system relied on gravity flow; therefore he "raised" Chicago by building the sewers above the existing streets and then covered them. By building tunnels beneath the lake into a new intake crib, he brought clean safe water to the city, allowing for continued growth.[3]

Although no thought had really been given to wastewater treatment, water disinfection had been studied and practiced for hundreds of years. Water disinfection can be dated back to 1500 B.C. when Egyptians first discovered the principle of coagulation and how it could be applied to particle settlement. Although at a very elementary level, the Egyptians sought to filter their water with coagulation and bag filters. However, rather than treating for pathogens, as pathogens had not been discovered, the water was being treated to taste better. In the 1700's domestic applications of water disinfection were applied. It had been known for a better part of history that boiling water would disinfect the water to a certain degree; however this was the first point in which water filters, made of wool sponge and charcoal, were used on a domestic level. In 1804 the first municipal water treatment plant was constructed by Robert Thom in Scotland. This treatment plant was based on slow sand filtration. At this point it time it became suggested that all people should have access to safe drinking water, however this concept would take much longer to be applied.

Early sewer systems were not nearly as intricate or advanced as today's systems. Waste was discharged to cesspools, privy vaults and surface waters until the middle of the nineteenth century. Cesspools are underground chambers built to hold wastewater until it can be absorbed by soil. They are considered to be the predecessors to modern-day septic systems. Cesspools are viewed today as public health hazards, mostly due to the risk of groundwater contamination.[4] A typical cesspool can be seen in Figure 2.

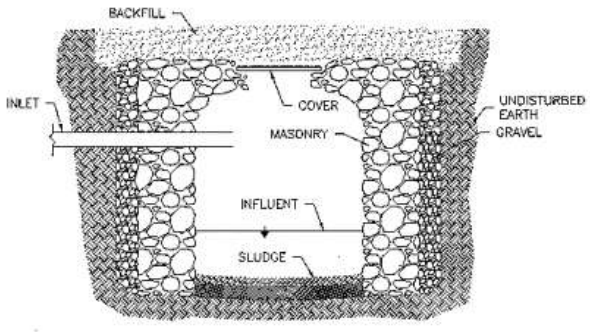

Figure 2: Cross-Section of a Cesspool
http://www.cefns.nau.edu/Projects/WDP/resources/treatmentsyst/Cesspool.htm

[3] *The History of Drinking Water Treatment.*
[4] *Onsite Wastewater Demonstration Project*

A privy, commonly referred to as an outhouse, usually has a vault located directly below for storage or leeching of waste. Like cesspools, many communities view them as public health hazards, and they are generally no longer in use.[5] Figure 3 shows a common privy vault.

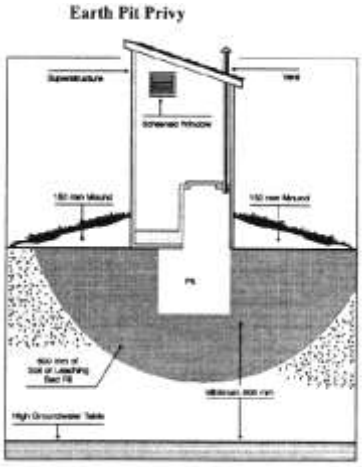

Figure 3: Privy Vault
http://www.publichealthgreybruce.on.ca/images/Sewage/PitPrivy.gif

It was not until 1847 that serious thought was given to further developments in sewerage and wastewater treatment. A cholera outbreak began in India and spread westward to London. A royal commission was appointed and found that one of the major problems concerning sewage in London was the lack of a central authority to handle it. Thus, in 1848 British Parliament created the Metropolitan Commission of Sewers. Cholera hit London that summer, killing 14,000 people within a year.[6] Dr. John Snow, an anesthesiologist and innovator in the field of epidemiology, concluded that cholera was spread through contaminated water, but neither local authorities nor medical professionals gave his theory much credence. During the cholera outbreak in 1854-55, Snow traced the disease to a pump on Broad Street in Soho, which he believed to be the source of the cholera.[7] In fear that human wastes caused the cholera outbreak, residents of London dumped their waste into the city's storm sewers, where it was carried to the nearest body of water. As this practice became more common, the drainage ditches were eventually covered and converted to sewers to contain the smell. This led to negative environmental consequences. The large amount of waste being discharged into relatively small streams overwhelmed the bodies of water. The smaller and eventually larger bodies of water began to ferment, thus creating a health problem, especially during dry and hot weather.[8]

The United States had followed on the coattails of Europe as it developed its sewer systems. The US experienced many disease outbreaks during the nineteenth century. Cholera struck in 1832,

[5] *The Sanitary Vault Privy: A Planning Guide and Minimum Requirements For the Construction of Vault Privies.* (1986).
[6] Viessman, Jr. et.al, p. 3
[7] *Broad Street Pump Outbreak*
[8] Viessman, Jr. et.al, p. 4

1849, and 1866, and typhoid in 1848. These outbreaks caused officials to see the need to construct sewer systems in US cities. However, such systems were slow to develop. US cities in the late nineteenth century were not as heavily populated as their European counterparts. By the end of the nineteenth century, many cities saw the need for separate storm and sanitary sewers, and the idea of wastewater treatment became more realistic. As the US population grew, increasing more than fourfold between 1850 and 1920, the population base shifted from rural areas to urban areas. During the same period, the US population in urban areas increased from 12.5 percent to 51 percent. The rapid growth of American cities greatly strained existing sewer systems, which were never designed to handle such high flows produced by so many people. Most sewers in the US at the time were combined systems, which, as they had in England, only transferred the health concerns from the inner cities to the nearest water bodies. At the start of the twentieth century, wastewater treatment technologies were still crude. The four most common types of wastewater treatment were dilution, irrigation of farmlands, filtration, and chemical precipitation. All of these technologies were usually only effective at treating smaller, wastewater-only flows, not the large flows from combined sewers found in most US cities. As more cities began discharging into rivers and lakes, the need for wastewater treatment became even more apparent.[9]

As strong as the argument for wastewater treatment was in the early twentieth century, there were more arguments against treating wastewater. Opponents to wastewater treatment questioned its need if drinking water treatment systems were in place, and claimed that the pollution problem could be solved by proper planning. Additionally, the economic burden of building two treatment works often caused municipalities to side on the opposition to wastewater treatment. This stance can clearly be seen in a published statement in a 1903 issue of *Engineering Record*, "…it is often more equitable to all concerned for an upper riparian city to discharge its sewage into a stream and a lower riparian city to filter the water of the same stream for a domestic supply, than for the former city to be forced to put in wastewater treatment works." Those in opposition to wastewater treatment were successful in their arguments during the early 1900's. In 1905, more than 95 percent of people in urban areas discharged untreated wastewater into waterways. By 1924, still more than 88 percent of the urban population in US cities over 100,000 discharged their waste directly into waterways.[10]

Things began to change for wastewater treatment proponents during the early 1900's. As the Progressive Movement swept through the US, more people began to focus on reducing pollution and preserving the natural state of waterways. Also, new laws were passed on the local and state levels advocating the protection of water quality. As these new laws were challenged in state courts, many cases were ruled in favor of downstream municipalities if sewage discharge from upstream municipalities created nuisance conditions. Also, many business groups, media outlets, and public health groups expressed favor of wastewater treatment. As studies were published that showed the relationship between wastewater discharge and disease transmission and as technology improved, more time was spent on finding cost-effective ways to treat wastewater. The turning point in the

[9] Burian, Nix, Pitt & Durans, 2000
[10] Ibid.

development of wastewater treatment technology in the early 1900's was activated sludge. Activated sludge was demonstrated to be a cost-effective way to treat large quantities of wastewater.[11]

Along with improving technologies, legislation played an important role in the eventual widespread construction of wastewater treatment works. The first water pollution legislation came in 1886, but it only dealt with dumping obstructions to safe navigation in New York Harbor. Congress then passed the River and Harbors Act in 1899, which outlawed dumping solid wastes into navigable waters. In 1912 the Public Health Service Act was passed, which included a section on waterborne diseases. In 1924, the Oil Pollution Act was passed, which prohibited oil discharges from ships into coastal waters. A key component of this act gave enforcement power to the federal government if local government failed to enforce the law. Another key component of this act was a provision for matching grants for waste-treatment facilities. In 1966, regulations were further strengthened by the passing of the Clean Rivers Restoration Act, which considered entire river basins in pollution control rather than localities. It also provided for a large increase in funding for the construction of wastewater treatment facilities. By 1970, the government recognized the need for more federal investment into the construction of wastewater treatment facilities. President Nixon proposed a four-year, $10 billion program of investment by federal, state and local governments in wastewater treatment facilities. In 1970 the National Environmental Policy Act (NEPA) was passed and the Environmental Protection Agency (EPA) was established. The EPA is the primary federal regulatory authority concerning all environmental issues.

The Clean Water Act was passed in 1987, which created the National Pollution Discharge Elimination System (NPDES). Through NPDES, the EPA has been able to place regulations on all discharges from wastewater treatment plants. Because the EPA places limits on what can be discharged, many plants have been forced to upgrade and expand their facilities to avoid heavy fines from the federal government.[12]

2.2 Regulatory Environment

The EPA is charged with protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress.[13] The EPA conducts environmental assessments, research and education. It maintains and enforces national standards through various environmental laws in consultation with state and local governments. For the most part, the EPA enforces these laws through fines, sanctions and other measures. The city of Gardner lies in Region 1 of the EPA along with the rest of New England.[14] Since 1970 the EPA has submitted and Congress has passed seven different acts all having to do with water and water quality. The EPA's main goal in regards to water is to ensure safe drinking water for all the public and has therefore set standards for more than 160,000 public water systems in the United States.[15]

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[11] Burian, Nix, Pitt & Durans, 2000
[12] Viessman, Jr. et.al, p. 8
[13] *Our Mission and What We Do*.
[14] *Public Access – When and how was the EPA Created?*
[15] Safe Drinking Water Act PL 93-523, 1974

NPDES is a program that seeks to protect and restore the quality of rivers, lakes, and coastal waters. Forty-four states and one territory are authorized to implement the NPDES program and its permits. The mission of the NPDES program is to shape national program direction by identifying issues of national or regional concern and developing strategies to address these issues. The NPDES program produces policies and regulations to address problems that affect the nation's waters. It develops technical and administrative tools to implement permits and it records and manages information on permit issuance, permit quality and point source pollution abatement. The EPA's water program seeks to support watershed planning, permit and program quality, consistency and innovation, standards to permits, modernize the permit management system, measuring environmental results, and finally, better communication and participation of stakeholders (states and territories, citizens, congress, etc.).[16]

The actual NPDES permitting process involves a multitude of steps. First, the operator of a facility must submit an application to a permit writer. The permit writer then reviews the application for completeness and accuracy and decides whether to continue with the permit or not. Once the decision is made to draft a permit, the permit writer uses application data and the fact sheet or statement of basis to develop the permit. The permit writer derives technology-based effluent limits. Following this step the permit writer derives effluent limits that are protective of state water quality standards such as water quality-based effluent limits. These two limits, technology-based and state water quality standards, are compared and the more stringent of the limits are applied to the permits. A permit may have some limits that are technology-based and other limits that are water quality based. Once the effluent limits are developed, the permit writer develops appropriate monitoring and reporting conditions, facility-specific special conditions and includes standard conditions that are consistent throughout all permits. After, the draft permit is completed; the permitting authority provides an opportunity for public participation in the process via public notice. The public notice announces the permit and anyone who is interested can submit comments regarding the draft permit. The permitting authority will then develop a final permit and issue it to the respective facility.[17]

2.3 US Environmental Protection Agency

In the 20th century, many strides toward environmental protection and conservation were made in the United States. On December 2, 1970 the EPA was established as an independent agency whose critical obligation was to protect and enhance the environment. The EPA's critical obligation was not only concerned with the deteriorating environment but also with establishing environmental standards, research, and the enforcement of set standards to protect against air and water pollution, solid waste disposal, radiation and the ill environmental effects of pesticides.[18] Currently, the EPA employs approximately 17,000 people and engages in many more employees on a contractual basis. Offices for

[16] Protecting the Nation's Waters Through Effective NPDES Permits, EPA, 2001-present, http://www.epa.gov/npdes/pubs/strategicplan.pdf
[17] Water Permitting 101, Office of Wastewater management, EPA, http://www.epa.gov/npdes/pubs/101pape.pdf
[18] http://www.epa.gov/aboutepa/history/publications/print/origins.html

the EPA include the agency headquarters in Washington D.C. as well as regional offices in each of the agency's 10 regions throughout the U.S.[19]

The environmental status of the US had became grave with examples such as the Cuyahoga River fires and a rupture of one of Union Oil's platforms off the Pacific coast near Santa Barbara, CA. In an effort to fight and win World War II, there was a major increase in industrial production which resulted in extremely dangerous amounts of industrial pollution in both air and water bodies. The Cuyahoga River was described in *Time Magazine* as the river that "oozes rather than flows" and in which a person "does not drown but decays." In 1969 the most detrimental of Cuyahoga River fires occurred resulting in over $1 million in damage to boats and riverfront office buildings that captured the attention of the nation. Industries were discharging anything and everything from their facilities into the river, which resulted in its described state and zero marine life. On the west coast, 100,000 barrels of oil flowed out in the Union Oil spill into the ocean, polluting a 60-mile stretch of coastline. This severely disrupted the natural balance of the Channel Islands offshore and did serious damage to fishing and other activities which were a vital part of the local economy. Led by Senator Gaylord Nelson of Wisconsin, who had been an avid spokesperson for environmental and water quality awareness for many years, the National Environmental Policy Act of 1969 was introduced. Fueled by the Santa Barbara spill and the status of the Cuyahoga River, NEPA was passed by the Senate.[20]

Prior to the establishment of the Environmental Protection Agency, President Nixon set up the Environmental Quality Council, whose main objective was to address the public's concerns on issues of the Santa Barbara spill and Cuyahoga River. Although during his election campaign, Nixon focused more on foreign policy and increase in crime in the US rather than environmental issues and policy, he was the first president to make concrete strides toward developing water quality standards and fight water pollution in the US. On July 9, 1970, Nixon decided to support the recommendations made by chairmen of the Council on Environmental Quality (previously known as the Environmental Quality Council) Russell E. Train and John Ehrlichman. Ehrlichman was the head of a White House committee devoted to examining current environmental policy, and sent the Reorganization Plan No. 3 to Congress. This plan's goal was to consolidate different departments, such as the Interior and Agricultural, Health, Education and Welfare and Transportation Departments into one government agency. Finally, as a result of the growth in national awareness of water pollution in the US, the Environmental Protection Agency was established. Soon after, William D. Ruckelshaus, Assistant Attorney General at the time, was nominated by the President as the EPA's first Administrator and was quickly confirmed by the Senate. The EPA then began operations on December 2, 1970.[21]

One of the first acts of the newly established EPA was to establish standards for discharge of pollutants into surface waters. In response to the Cuyahoga River fires, the Clean Water Act (CWA), which became effective on October 18, 1972, established goals of eliminating releases of high amounts of toxic substances into water by 1985. The main focus of the CWA was surface waters such as lakes and

[19] http://www.epa.gov/aboutepa/index.html
[20] http://domestic.nixonfoundation.org/2010/06/14/rn-and-the-formation-of-the-epa-3/
[21] http://domestic.nixonfoundation.org/2010/06/14/rn-and-the-formation-of-the-epa-3/

rivers rather than groundwater. More specifically it was established to affect "all waters with a significant nexus to navigable waters."[22] The CWA set regulations for industrial facilities, municipal governments and government facilities as well as some agricultural facilities. Basically, the CWA sought to abandon the previous approach that state and local governments were primarily responsible for ensuring water quality and moved to a national standard. The CWA made it illegal to discharge pollutants unless the discharger first obtained a permit from the government. It was determined that virtually nothing had been achieved by relying on state action to reduce water pollution in the previous years and as a result Congress established the CWA and sought to better relations between the federal government and states to achieve real water quality improvements.[23]

2.4 National Pollutant Discharge Elimination System

The Clean Water Act established the National Pollutant Discharge Elimination System Program or NPDES. NPDES main objective was to control "point source" or direct discharge from pipes and sewers. The CWA made it unlawful for any discharge into the nation's waters without first being authorized by a permit obtained for the EPA or an authorized state/tribe. Under section 402 of the CWA, NPDES was created effecting more than 65,000 industrial and municipal dischargers. A NPDES permit contains industry-specific, technology-based and water quality based limits and establishes pollutant monitoring and reporting requirements. A facility seeking a NPDES permit must provide quantitative analytical data that identifies the different types of pollutants present in the facilities effluent discharge. Dependent on the data, available technology, and industry, the permit will set conditions and limitations for the effluent that the facility seeks to discharge. Not only does a NPDES permit set limitations based on the industry, technology and pollutant data, it also considers aquatic life and recreation, as well as specific federal and state/tribe water quality standards for surface waters. Unlike technology driven standards, limitations based on aquatic life and recreation rarely take into account the feasibility or costs of said limitations.

Although standards between facilities and states may be similar, each is specific to that facility and the circumstances of the effluent and surface water quality and use. The NPDES permit requires industries to attain the best practicable control technology for each pollutant that is discharged. NPDES permits are issued every 5 years and must be renewed in order to maintain continued discharge. Once a permit is established for a facility, that facility is required to maintain records of day to day activities as well as effluent monitoring. The EPA can enforce the Clean Water Act through the NPDES permit and can issue compliance orders and civil suits against any person in violation of their NPDES permit. Penalties for noncompliance can range anywhere from $25,000 a day to as much as $250,000 a day, and/or can result in the incarceration of violators for a maximum of 15 years for the "knowing endangerment" of public health.[24]

[22] http://www.epa.gov/oecaagct/lcwa.html
[23] http://www.epa.gov/oecaagct/lcwa.html
[24] Ibid.

2.5 City of Gardner, Massachusetts

Gardner, established in 1785, is a small city located about 60 miles northwest of Boston and about 25 miles northwest of Worcester, MA. Its location is shown below in Figure 4. It is named after Colonel Thomas Gardner who was fatally wounded in the battle of Bunker Hill. The majority of Gardner's economy is centered on the large amount of furniture manufacturers in the city, so much so that it is sometimes referred to as the "Furniture Capital of New England". The city is composed of 23 square miles and is home to about twenty one thousand residents.[25] Gardner's public water supply draws the majority of its water from surface water supplies that are comprised of Cowee Pond, Pearly Brook Reservoir, and Crystal Lake. The Snake Pond well is used only during summer months. Only a small portion of the city's residents get water from private wells.[26]

Figure 4: Location of Gardner, Massachusetts
http://www.bestplaces.net/city/massachusetts/gardner

2.6 Gardner Wastewater Treatment Facility

The residents of Gardner are served by the city's sewer system. The system is comprised of over 30 miles of sewer mains, and the wastewater ultimately makes its way to Gardner's wastewater treatment facility. The facility is located at 52 Plant Road in East Templeton, Massachusetts. The plant serves 20,000 customers from Gardner, along with approximately 1,680 people in the town of Ashburnham and about 150 people from East Templeton. It was built in 1946, and major upgrades were finished in both 1963 and 1988. The Gardner Wastewater Treatment Facility (WWTF) also receives flow from 43 industrial users, leachate from the sludge landfill, and septage from recreational vehicles. The plant, which can be seen below in Figure 5, is a publicly owned treatment works (POTW) owned by the city of Gardner, but has been operated by a private contractor since 1998. The current operator of the Gardner WWTF is United Water.[27] United Water has been in operation since 1869, and is currently one of the United States' largest water & wastewater utilities. It serves over 200 communities in 22 states

[25] *About the City.*
[26] *Annual Water Report.* (2011).
[27] Maguire Group, NPDES Permit Compliance Report, 2010, p. 10

and employs 2,300 people in the US.[28] In addition to the day-to-day operation and maintenance of the plant, the firm also operates and maintains Gardner's water treatment and distribution systems as well as the city's sewer system.

Figure 5: Aerial View of the Gardner WWTF

Courtesy Bing Maps

http://www.bing.com/maps/#Y3A9NDIuNTY4Njg3NzE0OTk5NjZ+LTcyLjAyMDI2MjI5NDExODA0Jmx2bD0xNyZzdHk9cg==

The Gardner WWTF is a 5 million gallon per day (MGD) advanced wastewater treatment facility. It is regulated by NPDES Permit number MA0100994. The facility is permitted to treat an average daily flow of 5 MGD with a peak flow of 14 MGD. It experiences problems adequately treating the flows during periods of heavy rainfall or runoff, and is currently taking steps to ensure the plant is adequately treating its wastewater flow as much as possible. The city has begun an aggressive inflow and infiltration (I/I) program, aimed at reducing flow into the plant. Through lining problem sewers, the city has seen a reduction of about 600,000 gallons per day of influent flow into the facility. The city is also in the preliminary design phase of a plant upgrade aimed at regulating its influent flow.[29] The existing plant layout is below in Figure 6.

[28] *Facts & Figures: By the Numbers.* (2012).

[29] Maguire Group, NPDES Permit Compliance Report, 2010, p. 10

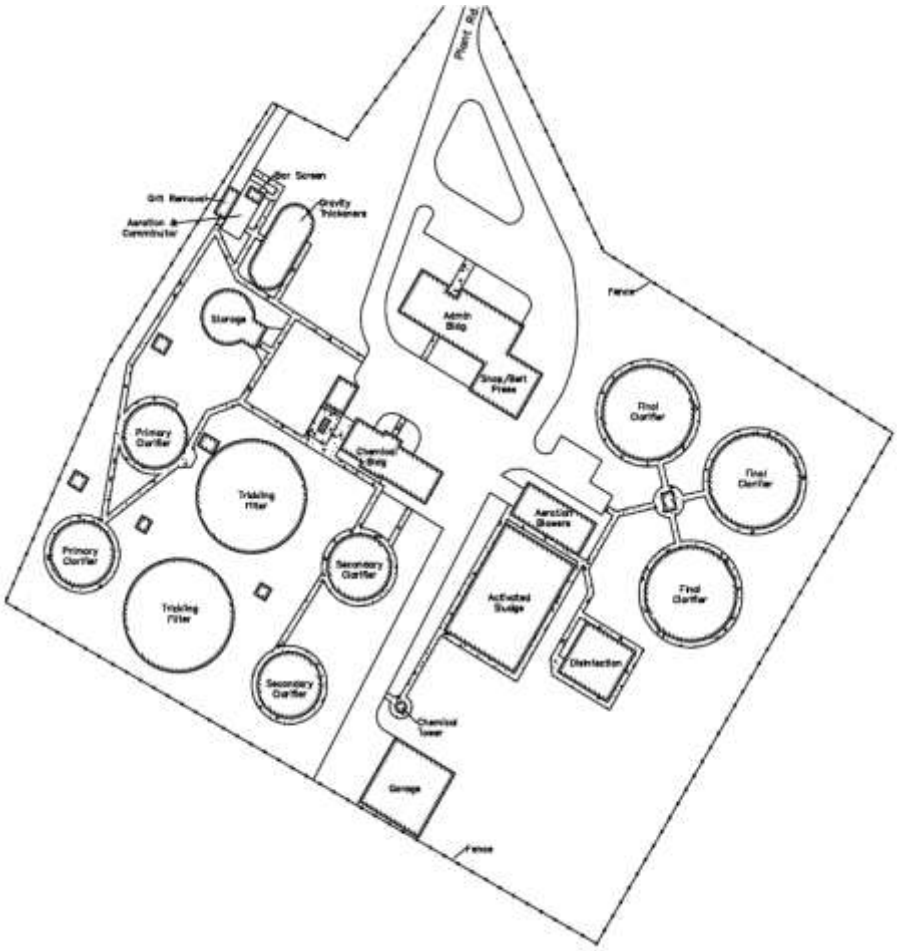


Figure 6: Gardner WWTF Layout

There are several stages of treatment currently working at the Gardner plant. Figure 7 below shows the flow diagram for the Gardner WWTF. The plant receives flow at the enclosed headworks, which consists of a mechanical bar screen, aerated grit chamber and comminutor. The plant headworks can be seen below in Figure 8. From there, flow goes to one of two primary clarifiers for solids removal, which can be seen in Figure 9. Secondary treatment consists of two trickling filters and two intermediate clarifiers, seen in Figure 10. Further treatment is accomplished through an activated sludge system, which can be seen below in Figure 11, and three final clarifiers. From there, the flow moves to chlorine contact tanks for chlorination and dechlorination, seen in Figure 12. The final effluent is discharged through outfall 0001 to the Otter River, which can be seen below in Figure 13. The discharge is located approximately 9.7 miles upstream of the confluence of the Otter River with the Millers River, in the Millers River Basin. The effluent eventually makes its way to the Connecticut River and finally to the Long Island Sound. Several chemicals are used in the process. Lime is added for pH control, ferric chloride for phosphorous removal, sodium hypochlorate is used for disinfection and sodium bisulphate is added for dechlorination. The plant's sludge treatment consists of gravity thickeners seen in Figure 14, a sludge holding tank and two belt filter presses for dewatering, which can

be seen below in Figure 15. The sludge is then trucked to the lined, city-owned, sludge-only landfill for mixing, spreading and covering.[30] Several chemicals are used to treat wastewater at the Gardner plant. The plant also has an onsite emergency generator to ensure it can remain operational in the event of a power failure. The influent flow is measured at the headworks and the effluent flow is measured just before the chlorine contact tanks.[31]

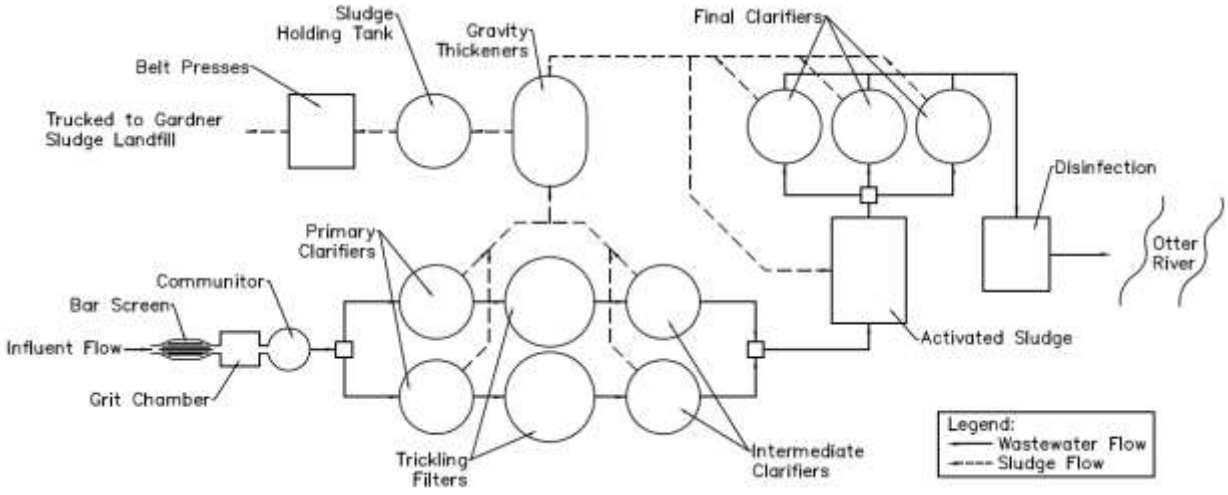


Figure 7: Flow Diagram of Gardner WWTF

Figure 8: Gardner WWTF headworks building

[30] *United Water in Gardner, Massachusetts.* (2011).
[31] Maguire Group, NPDES Permit Compliance Report, 2010, p. 10

Figure 9: Gardner WWTF primary clarifiers

Figure 10: Trickling filters at the Gardner WWTF

Figure 11: Gardner WWTF activated sludge

Figure 12: Chlorine contact tank for disinfection

Figure 13: Otter River just downstream of the Gardner WWTF

Figure 14: Gardner WWTF gravity thickener

Figure 15: Belt press at the Gardner WWTF

2.7 Management and Operation of WWTF

Currently the Gardner WWTF operates 7 days a week with 5 employees working at different times throughout the week. Regularly, there are three operators at the plant, a certified electrician and a mechanic. The 5 employees have a multitude of responsibilities and no employee is responsible for one specific task. For instance, the operators are not only responsible for overall day-to-day plant operations, but also water testing, equipment maintenance, and other jobs. An example of another job that operators might perform is the disposal of the dewatered sludge from the plant. Dependent on who is working and has the availability, the plant employees are responsible for loading and transporting the sludge to the landfill themselves.

Although the certified electrician is responsible for the upkeep and maintenance of all controls and electronics of the plant, he is not limited to just that task. Other responsibilities like maintenance of process equipment, transportation equipment, etc. are also a part of the electrician's duties. Similar to that of the electrician, the mechanic employed at the wastewater treatment facility has a multifaceted job. Although he is mostly a truck mechanic, his skills are applied to all parts of the treatment process whether with the treatment equipment, building facility, or anywhere else his mechanical expertise can be applied. Overall, the 5 employees at the wastewater treatment facility assume not just the responsibilities that may be relevant to their title, but rather wherever their skills can be of use.

The WWTF for the City of Gardner is over fifty years old and at the time of its construction was one of the state-of-the-art systems constructed in the area. Despite its age, the plant continues to run at a very high and efficient level meeting almost all of the requirements implemented by the EPA for its effluent characteristics. Like most facilities, over time equipment and parts in the process wear and need upgrading. Currently, surveying is being performed at the plant for various upgrades throughout the process and facility. These upgrades have been planned for implementation in many different phases, as it would not be possible to upgrade everything all at once. Unlike a manufacturing process, a wastewater treatment facility has a constant flow of water and must treat that water at all times. Traditionally, any other manufacturing or industrial process can afford downtime to upgrade the parts necessary in their processes, where as in water treatment that is not possible. Any downtime at the

WWTF would result in untreated water being discharged into the receiving water body, which is in direct violation of EPA regulations. Therefore, wastewater treatment facilities must find ways to upgrade their facilities while still treating the water and achieving appropriate effluent characteristics.

A WWTF has a constant flow that must always be treated as the flow progresses throughout the process. The WWTF in Gardner has been doing this for quite some time now under the same conditions. Although the facility was state of the art at the time of its construction in 1946 that does not mean it is state of the art today. In actuality, the WWTF in Gardner is seriously outdated compared to other local facilities. Despite the age of the facility however, the plant continues to treat wastewater and meet its effluent limitations for the most part. As mentioned before, the WWTF has had trouble meeting the appropriate limits for copper and phosphorus in the effluent in the past. Our project was to determine if there was any way of treating the copper and phosphorus at the facility rather than doing another remote study focused on the source of high copper. If it was determined that something could be done to treat the copper at the facility, the new treatment and treatment equipment would be included in the already planned phases of upgrades. However, it was determined that there was no real way of treating for copper at the facility so no new plans for upgrades have been established and the city of Gardner will most likely have to perform another study to determine the source of copper and how to deal with it.

Despite the lack of conclusiveness of our research, upgrades to the facility are still relevant and will be established in the near future. Although these upgrades do not include any specific treatment for copper they do include upgrades to all parts of the process that will help make the current process a more efficient and complete one. The facility is doing its job currently, but with the upgrades the facility will do its job better, with a larger quantity of potential treated water and a more efficient way of treating that wastewater.

The first and most apparent upgrade for the WWTF is to its headworks. The headworks is at the head of the plant. At the headworks five primary functions are performed: sampling, flow measurement, chemical addition, screening, and grit removal. Most solid material is removed from the wastewater through bar screens, which act as large solid filters. The bar screens filter large objects such as cans and pieces of lumber out of the flow stream. The purpose of the headworks is to condition the wastewater for further treatment such as biological treatment downstream in the plant. Another solid material removed in the headworks is a substance called grit. Grit is defined as inorganic matter such as sand and gravel. The grit is inorganic and therefore does not need to be biologically treated and can simply be filtered out. In Gardner, the grit is separated from the wastewater in a grit machine. The grit machine separates, dewaters and collects the sand and gravel, which is then disposed of at the local landfill. As part of the upgrade to the headworks, an upgrade to the grit machine will also occur.

Upgrades to the Gardner WWTF also include the construction of equalization basins. The object of an equalization basin is to maintain a constant flow in the treatment plant especially during excess flow conditions. The equalization basin is meant to eliminate large and rapid changes in flow to the downstream treatment processes during periods of high influent flow. Gardner is considering four 250,000-gallon equalization basins to divert flow in the process if there is ever the need. Another opportunity that equalization basins present is the ability to separate nutrients like nitrogen and

phosphorus from the wastewater. The possibility of constructing an equalization basin with no oxygen is an example to treat for nitrogen before primary treatment takes place. The headworks, grit machine, and equalization basin are all part of pretreatment upgrades to the WWTF that will help downstream in the process and make it much more efficient and easier to treat the wastewater effectively.

Currently, the sludge holding tanks at the WWTF serve no other purpose other than containing and holding the sludge. Upgrades to the sludge holding tanks are another example of increasing the efficiency of the process and taking pressure off the treatment systems further downstream. Upgrading these sludge holding tanks would involve better separation of sludge from wastewater before moving the sludge to the dewatering process. By increasing the amount of sludge separated from wastewater in the sludge holding tanks, it will make for easier dewatering of sludge before the sludge is transported from the plant. If the sludge contains less wastewater, the dewatering sludge process will be much faster and more efficient. Instead of the sludge simply being contained, with upgrades to the sludge holding tanks it will allow for treatment to the sludge to occur while being contained in the holding tanks.

A more complicated and later phase of upgrades to the WWTF involves replacing the current siphons into the Otter River with newer ones. Over time these siphons have become worn, and although they still perform the operation they are meant to, new siphons would directly result in a more efficient process, significantly decreasing the need for maintenance and upkeep that the current siphons require. This upgrade is considered a much more difficult one because upgrading the siphons almost always means stopping or diverting flow in some way. A successful way of implementing this at the Gardner WWTF has yet to be discovered, however the upgrade is still a possibility. If the flow can somehow be diverted or discharged to the Otter River by different means temporarily, the upgrade of the discharge siphons will be a reality. As mentioned before, the current siphons do the job they are required to do, however because of the wear and tear over time, new siphons would result a significant decrease in required maintenance and upkeep of the system.

The final and potentially simpler upgrade to the WWTF will involve moving from using lime in treatment to using soda ash. Lime and soda ash are used in water treatment to add alkalinity to the water and adjust the pH. Lime treatment also has incidental benefits to remove iron, aid in clarification of turbid waters and has minimal bactericidal benefit. By moving from lime to soda ash, a better and more efficient addition of alkalinity and adjustment of pH can be expected. The soda ash better softens the water to permit for easier treatment of unwanted wastewater characteristics such as nitrogen and phosphorus compared to strictly lime. With the implementation of soda ash to the process instead of lime, treatment processes downstream will result in a significant increase of effectiveness with wastewater being softer and easier to treat2.8 NPDES Permit in Gardner, Massachusetts

The City of Gardner and more specifically the Department of Public Works and the Wastewater Treatment Facility must comply with NPDES permit No. MA0100994. This limitations for the treatment facility in Gardner that discharges to the Otter River. NPDES permit is the town of Ashburnham as a co-permittee as about 1600 residents in discharge into sewers that are treated at the Gardner WWTF. The NPDES permit became

December 1, 2009 and will be expire in 2014. Specific numbers for the effluent discharge shown below in
Table 1 and

Table 2.[32]

This NPDES permit is specific to the wastewater characteristics in Gardner. Although many of these effluent characteristics are present in almost all wastewater treatment facilities, the limitations are different and vary depending on present technology and where the effluent is discharged. The NPDES permit defines the terms in the tables below. It also defines when and what kind of samples shall be taken, and how they are to be reported in the Discharge Monitoring Report.

The wastewater treatment facility must develop a routine sampling program where samples are always taken at the same location, same time, and same days every month to insure maximum accuracy. All samples that are taken should be 24-hour composite samples unless it is specified otherwise in the permit. A 24-hour composite sample consists of at least twenty-four grab samples taken consecutively in a 24-hour period and should be combined proportional to flow.[33]

Table 1: Gardner WWTF effluent discharge limitations
NPDES Permit No. MA0100994

[32] NPDES Permit No. MA0100994, Part 1.A, p.2
[33] Ibid, p.3

Effluent Characteristic	Units	Effluent Limitations			Monitoring Requirements	
		Average Monthly	Average Weekly	Maximum Daily	Measurement Frequency	Sample Type[2]
Flow[1]	mgd	5.0 Report	*** ***	*** Report	Continuous	Recorder
BOD[3] (April 1 – October 31)	mg/l lbs/day	8.7 364	8.7 364	Report ***	2/week	24-hour composite[4]
BOD[3] (November 1 – March 31)	mg/l lbs/day	26.2 1093	39.3 1640	Report ***	2/week	24-hour composite[4]
TSS[3] (April 1 – October 31)	mg/l lbs/day	17.4 729	17.4 729	Report ***	2/week	24-hour composite[4]
TSS[3] (November 1 - March 31)	mg/l lbs/day	26.2 1093	39.3 1640	Report ***	2/week	24-hour composite[4]
pH[5]	s.u.	6.5 – 8.3			1/day	grab
Dissolved Oxygen[5] (April 1 – October 31)		NOT LESS THAN 6.0 mg/l AT ANY TIME			1/day	grab
E. coli[5,6] (April 1 – October 31)	cfu/100ml	126	***	409	1/week	grab
Total Residual Chlorine[7,8] (April 1 – October 31)	ug/l	15	***	26	1/day	grab
Total Phosphorus[9] (April 1 – October 31)	mg/l lbs/day	0.12 5.0	*** ***	Report Report	2/week	24-hour composite[4]
(November 1 – March 31)	mg/l lbs/day	1.0 41.7	*** ***	Report Report	1/week	24-hour composite[4]

Table 2: Gardner WWTF effluent discharge limitations continued

NPDES Permit No. MA0100994

Effluent Characteristic	Units	Effluent Limitations			Monitoring Requirements	
		Average Monthly	Average Weekly	Maximum Daily	Measurement Frequency	Sample Type[2]
Dissolved orthophosphate (November 1 –March 31)	mg/l	Report	***	***	1/week	24-hour composite[4]
Total Nitrogen[3,10]	mg/l lbs/day	Report Report	*** ***	Report Report	1/week	24-hour composite[4]
Total Kjeldahl Nitrogen[3]	mg/l	Report	***	Report	1/week	24-hour composite[4]
Total Ammonia Nitrogen[3] (June 1 – October 31)	mg/l lbs/day	1.0 Report	1.0 Report	*** ***	1/week	24-hour composite[4]
(November 1 – May 31)	mg/l lbs/day	4.4 Report	4.4 Report	*** ***	1/week	
Nitrate + Nitrite[3]	mg/l	Report	***	Report	1/week	24-hour composite[4]
Aluminum	ug/l	87	***	Report	1/month	24-hour composite[4]
Cadmium[11]	ug/l	0.5	***	Report	1/month	24-hour composite[4]
Copper[12]	ug/l	13.6	***	22.0	1/month	24-hour composite[4]
Lead[13]	ug/l	4.4	***	Report	1/month	24-hour composite[4]
Mercury[14]	ug/l	1.3	***	2.3	1/month	24-hour composite[4]
Whole Effluent Toxicity[15,16,17]	%	Acute LC50 ≥100% Chronic NOEC ≥ 72%			1/quarter	24-hour composite[4]

All discharges from the wastewater treatment facility to the Otter River at outfall 001 must be in accordance with the terms and conditions of the NPDES permit. Discharges from any other point sources, such as sanitary sewer overflows (SSOs) must be reported to the MassDEP separately on an SSO reporting form. Other conditions that are not regulated by the NPDES permit must be reported in a fashion similar to that of a sanitary sewer overflow and the respective forms must be submitted to the MassDEP.[34]

The NPDES permit describes more general characteristics of the effluent discharge that are not as specific as the limitations described previously. The discharge must not cause a violation of the water quality standards of the receiving waters which are determined by the state or local governments. The discharge must not cause objectionable discoloration of the receiving waters. The effluent shall not contain a visible oil sheen, foam, or floating solids at any time. The treatment facility must maintain a minimum of 85% removal of both total suspended solids and biochemical oxygen demand. If the average annual flow in any year exceeds 80% of the facilities designed flow, it must be reported to the MassDEP. This report should describe plans for future flow increases and how the facility will maintain compliance with the set limitations. Any new introduction of pollutants into the treatment facility from an indirect source as well as any substantial change in the volume or characteristics of pollutants being introduced into the treatment facility must also be reported.[35] Specific to toxic control in the effluent, the treatment facility cannot discharge any pollutant or combination of pollutants in toxic amounts nor shall any components of the effluent result in demonstrable harm to aquatic life or recreation in the receiving waters. [36]

2.8.1 Operation and Maintenance of the Sewer System Defined by NPDES

The treatment facility must provide an adequate staff to carry out the operation, maintenance, repair and testing functions required in order to comply with the terms and conditions of the permit. There must be an ongoing preventative maintenance program in place to prevent overflows and any potential bypasses. The program must also include an inspection function designed to identify any potential and actual unauthorized discharges. The facility must have an infiltration/inflow control plan that is to be submitted to the EPA and MassDEP within six months of the effective date of the NPDES permit and should described all actions taken by the treatment facility for preventing I/I that could result in violation of effluent limitations and unauthorized discharges of wastewater. Finally, in order to ensure compliance with the NPDES permit, the facility must always have an alternative power source to power and sufficiently operate the treatment works.[37]

2.8.2 Sludge Conditions

The NPDES permit also outlines the regulations for sludge conditions and how to dispose of the sludge in different ways. The treatment facility must first comply with all federal and state laws that apply to sewage sludge use and the disposal of that sludge. The treatment facility is ordered to comply with the more stringent of the two. As for the disposal of the sludge the NPDES permit highlights three

[34] NPDES Permit No. MA0100994, Part B, p. 7
[35] NPDES Permit No. MA0100994, Part 1.A.1 and 2, p.6
[36] NPDES Permit No. MA0100994, Part 1.A. 4, p.7
[37] NPDES Permit No. MA0100994, Part C, p. 8

different methods. The first is land application of the sludge and using it to condition or fertilize the soil. The second is surface disposal which is the placement of the sludge in a sludge only landfill. Finally, the last method of removal of the sludge is to incinerate the sludge in a sludge only incinerator. If the facility places the sludge within a municipal solid waste landfill or instead of disposing the sludge the facility treats the sludge using, for instance, lagoons or reed beds, the conditions of the permit and the sludge conditions do not apply. In the case of Gardner, their sludge is distributed to a sludge only landfill.[38] The facility must monitor the pollutant concentrations, pathogen reduction and vector attraction reduction of the sludge at a frequency dependent on the volume of the sludge. The frequencies are shown below in Table 3.[39] An annual report of the sludge conditions and all information concerning the guidelines of sludge conditions must be submitted to the EPA and MassDEP.

Table 3: Sludge frequency monitoring

NPDES Permit No. MA0100994

Volume of dry sludge	Frequency
less than 290	1/year
290 to less than 1,500	1/quarter
1,500 to less than 15,000	6/year
Over 15,000	1/month

2.8.3 Special Conditions

The NPDES permit has a special conditions section specific to Gardner and the characteristics of the city's wastewater. These special conditions discuss two different characteristics of the wastewater: total phosphorus and total nitrogen. This section gives the treatment facility a certain amount of extra time to fall in compliance with the limitations set for each characteristic. These special conditions allow for the treatment facility to perform an evaluation of whether the facility is capable of reliably achieving the set effluent limitations before they must fully comply. If they cannot achieve the set limitations for total phosphorus and nitrogen the city must submit an annual report describing how it is progressing toward achieving the effluent limitations and what planning, design and construction is being implemented in the facility. The facility is allowed to discharge total phosphorus at a monthly average limit of 0.2 mg/l until the limit becomes effective in April 2013. For total nitrogen, the annual average must be no more than 450 lbs/day and an annual report must be submitted to EPA and MassDEP describing the strides being made toward optimizing nitrogen removal so that the facility can fall under compliance with the NPDES permit.[40]

2.8.4 Industrial Pretreatment

In compliance with the NPDES permit, the city must develop and enforce local effluent limits for industrial users to ensure the facility maintains effluent limitations and sludge disposal methods. The effected industries must have ample notice and time to have the opportunity to respond to the pretreatment necessary in their production or manufacturing processes. The city must prepare and submit a technical evaluation analyzing the need to adjust local limits, assessing how the treatment

[38] NPDES Permit No. MA0100994, Part D, p.9
[39] Ibid, p. 10
[40] NPDES Permit No. MA0100994, Part E, p. 11-12

facility performs with respect to influent and effluent pollutants, as well as water quality concerns, sludge quality, sludge processing concerns, and biomonitoring results. If the local limits must be revised, a technical evaluation form of the local limits must be submitted to the EPA and MassDEP and the local limits must be revised within 120 days of notification by the EPA and submit the revisions for approval.

The city must implement an Industrial Pretreatment Program in accordance with legal authorities, policies, procedures, and financial provisions that are described in the city's approved Pretreatment Program. The city must perform inspection, surveillance and monitoring of the industries, which will determine whether the industry is in compliance with the pretreatment standards. The city must also obtain remedies for noncompliance by any industrial user with any pretreatment requirement.[41]

2.8.5 Industrial Pretreatment Case Study

In order to better understand what actually entails pretreatment at an industry before discharge a local company that has a large pretreatment system in place was researched and studied. Vitasoy USA is a tofu manufacturer located in Ayer, MA. Although this industry is not in Gardner and does not discharge to the Gardner WWTF, it is part of a very large-scale industrial pretreatment program. The tofu manufacturing process uses an enormous amount of water, more so than most other industries, and is not very similar to the industries located in Gardner, MA. The purpose of this case study was to break down and determine what actually makes up industrial pretreatment of wastewater and the cost, chemicals, and processes associated with it. Although Vitasoy does use an extremely large amount of water, the goal of this case study is to display industrial pretreatment on a large scale.

From April 2010 to March 2011, Vitasoy had a total wastewater flow of 32, 164, 986 gallons with a total wastewater treatment and air scrubber system cost of $187, 645. The process uses various chemicals that are added to the wastewater for purposes such has pH control, sludge settling and foam control. Costs included in the total costs are the cost of chemicals, lab testing, repairs and labor cost. Not only does Vitasoy treat their wastewater, but it also develops sludge through the process that must be handled and treated separate to the wastewater and air scrubber system.

Unlike the wastewater treatment and air scrubber system, the sludge dewatering operation takes the sludge that is developed during the treatment process and dewaters it developing a cake-like substance. Once the sludge is dewatered, it is then stored and transported to a local farm where the farm owner uses the sludge for fertilizer. Costs included in the sludge dewatering operation include the costs of chemicals, transportation, D-Earth cost, repairs and labor. The total cost of the sludge dewatering operation is $283, 800.

Together the wastewater treatment and air scrubber system, along with the sludge dewatering operation totaled $471, 445 from April 2010 to March 2011. With 32, 164, 986 gallons being treated in that time period, the treatment cost was $.01465 per gallon.

[41] NPDES Permit No. MA0100994, Part F, p. 12-13

No industrial pretreatment process is ever going to be exactly the same and it dependent on the type of industry. Because tofu manufacturing requires large amounts of water, the pretreatment system is a very large one. However, in Gardner, most local industries would not qualify for such a large scale operation as these industries are furniture manufacturers, metal finishing industries and other various low water processes. Nevertheless, if it were ever determined that a company that discharges to the Gardner sewage system did qualify for industrial pretreatment, the cost per gallon can be expected to be similar to that of Vitasoy USA. The cost figures are displayed below in Table 4.

Table 4: Industrtial Pretreatment Costs

Wastewater Treatment process and Air Scrubber system		Sludge Dewatering Operation		Total Wastewater Cost	Cost per gallon of Wastewater
Chemical Cost	$63,468	Chemical cost	$57, 920	$471, 445	$.01465
Lab Test Cost	$39, 377	Transportation	$111, 800		
Repair Cost	$19, 800	D-Earth Cost	$49, 280		
Labor Cost	$65, 000	Repair Cost	$ 19, 800		
		Labor Cost	$45,000		
Total Cost	$187, 645	Total Cost	$283, 800		

2.9 Sources of Copper Contamination

There are many places where copper can originate from in the water cycle. Copper is naturally found in water at low levels between 50 and 100 ppb in drinking reservoirs.[42] Even lower levels are found in groundwater sources, averaging only 5 ppb. The city of Gardner has 113 private wells that discharge into the city sewer line. This means that the majority of Gardner's water supply comes from the water treatment facility, where the copper levels could be as high as the EPA limit of 1300 ppb, although the actual level is much lower. The city samples the water at various locations around the city, usually areas furthest from the treatment plant, where the copper levels have been reported consistently under the EPA wastewater discharge limit for Gardner. With 5 million gallons of wastewater entering the plant daily at an average of 100 ppb, the root of the copper is not from the water sources.

Copper piping is of major concern when locating the source of the copper. Almost all hot water pipes, as well as some cold water pipes are made of copper. Mildly corrosive water with a pH slightly above or below 7 could affect the piping system and elevate the copper level in the water. Additionally,

[42] Maag et al.

copper particles are more likely to release in hot water applications, such as hot water heaters used in every household. One study suggests that the copper plumbing accounts for 14-61% of the total copper in wastewater. If copper plumbing is in fact contributing significantly to the total copper entering the WWTF, measures can be taken to reduce the corrosive level leaving the treatment plant. With the WWTF operating at the same level of efficiency of copper removal, and with a reduction of 61% of copper entering the plant, the discharge copper level should be well within EPA limits. [43]

Root killer (copper sulfate) is a common homeowner tool used to remove roots from septic pipes. The product is dumped directly into the sewer lines and, being of high copper concentration, could potentially be a source of copper in wastewater. Root killer would also explain sporadic copper levels experienced in the Gardner WWTF. Unfortunately, it is difficult to prove root killer as a copper source because the source location varies as the product is used at different locations. To overcome this difficulty, root killer sales can be tracked within the area of the Gardner wastewater collection area.[44]

Industrial facilities in the area are a high probability of copper infiltration. Some of the industries in the Gardner area are metal finishing companies that could dispose of copper particles in the sewer system. Some metal finishing processes could also result in a chemical abrasion of the metal, dissolving it, which would in-turn end in the sewer system. Copper is also a dominant ingredient in batteries and metal plating. Excess material from these companies could result in an overall increase of copper in the Gardner WWTF.[45]

In addition to root killer, copper sulfate is also used to treat algae. One reason that the EPA sets strict limits on copper discharge is because of the hazard it poses to the wildlife. One study suggests that the algae treatment “Bluestone” has the potential to kill fish in small water systems. Although small water systems are neither a drinking source nor a wastewater depository, contamination of the small system could reach the WWTF by infiltration and inflow. The effect of Bluestone is based on the alkalinity of the water. The higher the alkalinity, the more copper sulfate is necessary for proper treatment. If algae treatment is present in high alkaline waters in Gardner, it could be a source of copper entering the WWTF.[46]

2.10 Copper in Plant Effluent

One of the biggest challenges in meeting the NPDES permit limits faced by the operator of the Gardner WWTF is the total copper discharge limit. In order to determine where the copper was actually coming from and how the treatment facility could lower these levels many studies were performed. In June 1994, the city of Gardner conducted a corrosion control study to comply with the Safe Drinking Water Act Lead and Copper Rule. This study revealed that the city’s source water was corrosive and therefore led to leaching of copper into the water from building plumbing. These findings led to full-scale chemical precipitation trials with ferric chloride and the effect it would have on the copper levels. The trials concluded that ferric chloride had the ability to reduce copper levels in effluent, but not

[43] Sprague
[44] Ibid
[45] Ibid
[46] Ibid

enough to comply with the limitations set by the NPDES permit at that time. As a result, the city of Gardner re-evaluated the local limits and revisited copper sources that entered the collection system. The evaluation determined that adjusting the local limits under the city's industrial pretreatment program was no viable due to the fact that the local industries attributed to such a small portion of the copper in the wastewater. Adjusting the local limits would not reduce the amount of copper enough to comply with the NPDES permit at that time. Corrosion control during water treatment and chemical addition at the water treatment plant would be necessary in order to comply with the NPDES permit.[47]

In 2002, the contract operator at the time compiled a report that described the corrosion control program efforts that were in effect and its successes in reducing the copper levels that were discharged. In addition, the report described how further optimization of the corrosion control program would result in better copper removal.[48] In 2003 the city performed its own copper optimization study called the Wastewater System Copper Optimization Engineering Report. This report sought to completely identify all the sources of copper in the collection system and determine treatment options that were applicable to reduce the total copper concentration to the treatment facility. Some of the report's recommendations were to implement corrosion control inhibitors within the municipal system and an extensive infiltration and inflow reduction program to further reduce the copper levels loading into the treatment facility.[49]

Despite the studies and recommendations the city continued to fail to meet the NPDES permit discharge limits through 2008. During this time the EPA issued three Administrative Orders that required the city of Gardner to take definitive actions to reduce the copper effluent levels. The first two Administrative Orders were complied with by the city, leaving the last and most recent Administrative Order the only active one. The Maguire Group and the city of Gardner submitted a "Copper Report" to the EPA and MassDEP in December of 2010 in order to satisfy the requirements of the final Administrative Order.[50]

The NPDES permit had been revised in 2009 adjusting more stringent limitations for certain effluent characteristics such as aluminum, copper and phosphorus. The previous NPDES permit had much more strict limitations but did not take into account the combined $CaCO_3$ hardness downstream of the wastewater treatment plant or the in-stream copper concentration of the Otter River. As a result, the limitations had been adjusted to better fit the actual characteristics of the effluent and actual levels. Specifically for copper, the limit had been adjusted from 3.3 ug/L to 13.6 ug/L. [51]

2.11 Case Study

A study was conducted at the San Jose/Santa Clara water pollution control plant on the removal of copper and nickel. The plant processes on average 167 million gallons per day, and has a copper discharge limit of 4.9 ppb (1998). Similar to the task assigned by the Gardner WWTF, "This paper

[47] NPDES Permit No. MA0100994, Part F, p. 15
[48] Ibid, p. 12
[49] Ibid, p. 15
[50] Maguire Group, NPDES Permit Compliance Report, 2010, p. 13
[51] Maguire Group, NPDES Permit Compliance Report, 2010, p. 17

describes the results of an investigation of the in-plant fate of Cu undertaken to develop methods for complying with the [new regulations]." Although this study is dated by modern technology, both in copper testing and removal, there are many similarities between attempting to test/remove copper at the San Jose/Santa Clara plant and the Gardner WWTF.[52]

Composite samples were taken from multiple points throughout the plant. The plant schematics are are shown below in Figure 16, as well as the copper concentration throughout the control plant in

Table 5, indicating the amount of copper that was dissolved versus the amount that was particulate matter and the total copper values. The average influent and effluent copper values are very similar to those at the Gardner WWTF, just over 100 ppb and below 10 ppb respectively. The California plant has a limit of 9.0 ppb set in 1993;[53] a higher expectation to meet during a time of less technological options for treatment when compared to Gardner's limit.

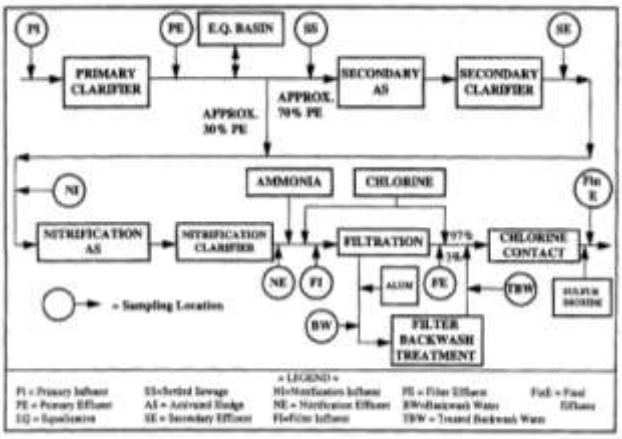


Figure 16: Flow diagram and sampling locations for in-plant metal study
Ekster & Jenkins p. 1173

Table 5: Copper concentrations from June 22, 1993 to September 21, 1994
Ekster & Jenkins p. 1174

[52] Ekster & Jenkins, p. 1172
[53] Ibid, p. 1172

Sample location	Copper concentration, μg/l		
	Total	Dissolved	Particulate
Primary influent	109 ± 22 (101)	5.5 ± 3.2 (4.2)	104 ± 22 (96)
Primary effluent	62 ± 20 (60)	6.2 ± 4.0 (5.4)	57 ± 19 (54)
Settled wastewater	59 ± 16 (58)	4.8 ± 3.4 (3.6)	55 ± 17 (53)
Secondary effluent	4.3 ± 1.6 (4.0)	1.2 ± 0.5 (1.1)	3.1 ± 1.6 (2.9)
Nitrification influent	18 ± 4.5 (17)	2.3 ± 1.1 (2.0)	16 ± 4.5 (15)
Nitrification effluent	5.4 ± 1.4 (5.2)	2.0 ± 0.7 (1.9)	3.4 ± 1.5 (3.1)
Filter influent	5.0 ± 1.1 (5.0)	3.6 ± 1.1 (3.5)	1.4 ± 1.1 (1.3)
Filter effluent	4.2 ± 1.3 (3.8)	3.6 ± 1.1 (3.5)	0.6 ± 1.4 (0.3)
Final effluent	3.8 ± 1.0 (3.7)	3.5 ± 1.1 (3.4)	0.4 ± 0.9 (0.2)

Values are means ± SD; medians are in parentheses.

The method for testing copper concentrations is almost identical to those recommended in the 2005 version of Standard Methods for the Examination of Water and Wastewater (21st edition). Total copper concentration was measured by unfiltered digestion, while the dissolved copper concentration was filtered using 0.45 µm filters. The San Jose/Santa Clara test samples were preserved with HNO_3 to a pH under 2, while Gardner's samples were preserved with hydrochloric acid (HCl) to a pH under 3. The difference in pH used in preservation should not vary the test results.[54]

The majority of the copper removed throughout the treatment process was the copper while passing through the secondary activated sludge tank, indicated in Table 6. Additionally, the secondary activated sludge tank was the only process throughout the plant that made significant progress is removing dissolved copper, shown in Table 7, from 3.6 ppb to 1.1 ppb. Copper removed via the secondary activated sludge system varied seasonally, where the higher removals were associated with increased activated sludge growth. [55]

Table 6: Individual treatment process median copper and nickel removal efficiencies

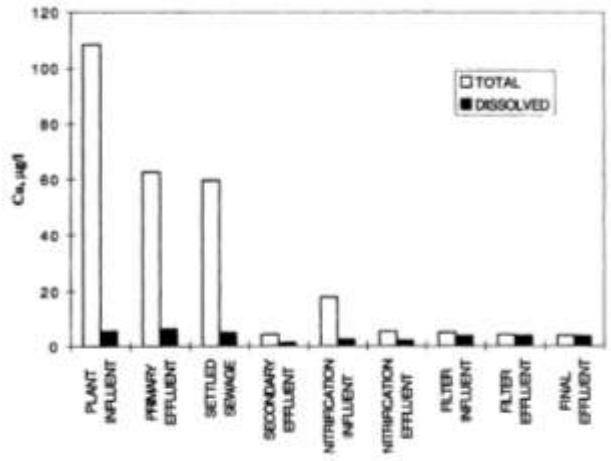
Ekster & Jenkins p. 1175

Treatment process	Removal efficiency, %						
	Copper			Nickel			Suspended solids
	Total	Dissolved	Particulate	Total	Dissolved	Particulate	
Primary	42	5.1	45	23	2.9	38	56
Secondary activated sludge	93	70	94	38	−2.8	86	91
Nitrification activated sludge	71	−5.6	80	19	6.0	58	80
Prefilter chloramination	2.6	0	68	−1.4	−1.2	50	0
Effluent filtration	19	0	70	1.1	−1.2	37	95
Overall treatment	96	31	>99	61	9.0	99	>99

Table 7: Fate of total and dissolved copper from June 22, 1993 to September 21, 1994

Ekster & Jenkins p. 1175

[54] Ekster & Jenkins, p. 1172
[55] Ibid, p. 1174



Overall, this study has shown that low copper discharge limits are attainable with proper treatment. The study suggests that to optimize copper removal, which has been determined is most active in the secondary activated sludge tanks, filtering without influent prechloramination is the best option. While there were many tests conducted on the level of chlorine used for treatment, the results were inconclusive, pointing to investing in a secondary activated sludge tank as the most efficient treatment option.[56]

[56]Ekster & Jenkins, p. 1178

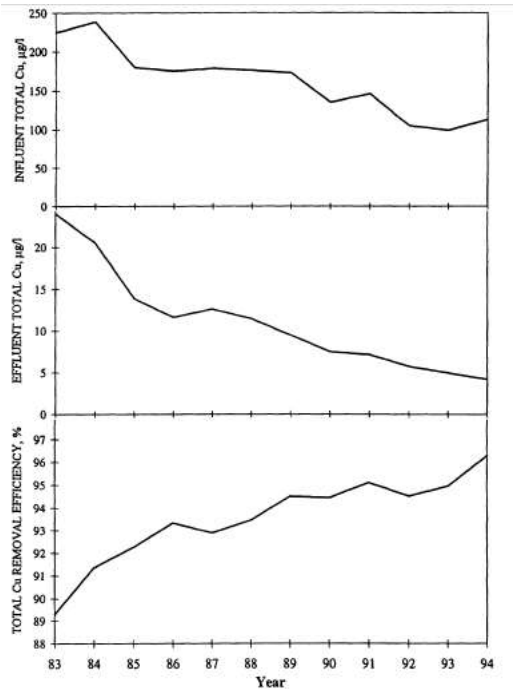


Figure 2—Annual average influent and final effluent total copper concentrations and annual average total copper removal efficiency.

Figure 17: Annual average influent & effluent total copper concentrations & copper removal efficiency

Ekster & Jenkins p. 1178

In addition to treating the waste water for copper, it may be worthwhile to investigate the treatment options at the water treatment plant. Over the 12 years of recorded data shown in Figure 17, there is a correlation between the decreased levels of copper in the wastewater effluent and the decreased level of copper leaving the water treatment plant. Treating the water before it enters the water distribution system could affect the corrosiveness of the water, which in copper pipes could be a major contributor to the copper entering the wastewater treatment plants.

Chapter 3: Methodology

The following chapter of this report describes the tasks completed to achieve the goals set forth in this project. One of the first steps in this project was to investigate the plant itself and conduct an extensive plant sampling routine. Another step was researching possible sources of copper contamination within the sewer collection system. As the project progressed, it was determined to attempt copper removal in the laboratory by removing particulate matter, and by precipitation. Hardness measurements and calculations were also conducted on the Otter River. While some of these objectives were accomplished simultaneously, some of our tasks originated after review of tasks we already completed. To accomplish the project's goals, the team did much research through literature and several manufacturers as well as interviews and laboratory experimentation.

3.1 Plant Sampling Routine

The first task was to determine where in the treatment process at the Gardner facility that copper removal was taking place and find out just how much copper was being removed by the plant. The goal was to pinpoint specific processes to determine if there were any processes in the plant that were not performing as they should in removing copper and to see where and what types of other systems may fit within the Gardner plant to complement the existing treatment processes with copper removal. To accomplish this task the group began a plant sampling study.

Before making the trip to Gardner to collect samples, it was necessary to determine where the samples needed to be retrieved from and what testing would be completed upon returning to WPI. Since there are four main treatment processes at work in the Gardner plant, the group decided to sample before and after each step. Samples were taken for each of the following: influent, primary treatment, secondary treatment, final treatment and effluent. It was determined that the samples had to be tested for both total and dissolved copper. After review of the *Standard Methods for the Examination of Water and Wastewater* and after speaking to Don Pellegrino, the lab manager for the WPI Civil and Environmental Engineering Department, the group decided to create a proper procedure for testing the samples.

The samples were analyzed in the laboratory using atomic-absorption spectroscopy (AA). AA measures the concentration of gas-phase atoms using the absorption of light. In order to get a reading, the sample must be vaporized in a flame or graphite furnace. In this process, the atoms absorb ultraviolet or visible light and make transitions to higher electronic energy levels. The concentration of the desired element is then determined from the amount of absorption. Concentration measurements are determined from a working curve, or calibration curve, obtained by measuring the signal from a series of known concentrations of the element. Once the calibration curve is determined the test can begin. The light source of the machine is a hollow-cathode lamp of the element that is being measured. Flame AA makes use of a slot type burner. Sample solutions are aspirated with the gas flow into a mixing chamber, forming small droplets before entering the flame. The graphite furnace is a much more efficient atomizer than a flame and can measure much smaller quantities of a sample. When using the furnace, samples are placed directly in the furnace and it is heated in several steps to dry the sample, ash organic matter, and finally vaporize the required atoms. For light separation and detection, AA

machines use monochromators and detectors for UV and visible light. The monochromator is mainly used to isolate the absorption line from background light due to interferences. A photomultiplier tube is then used to detect the concentration of an element in the sample. Photomultiplier tubes convert photons to an electrical signal that can be read by the computer. A readout is then printed, consisting of the calibration data and the test results. The machine tests each sample twice, reporting each reading and giving the mean of the two, which is the recorded result.[57] Use of the AA machine required that we prepare the samples properly before they could be tested, which will be explained in further detail in the coming paragraphs. Figure 18 shows the AA machine in WPI's Environmental Laboratory.

Figure 18: Atomic-absorption spectroscopy machine at WPI

The group made several trips to the Gardner WWTF for collection of samples between October 12, 2011 and February 16, 2012. The plant was visited a total of six times for the plant sampling routine, and samples were collected from the same location in the treatment process each time to ensure consistency of the results of the study. Once at the plant, the exact locations for sampling during each treatment stage were determined with the assistance of the plant operations staff. The influent samples were taken from the aerated grit chamber at the headworks building. The grit chamber is immediately following the bar screen and immediately before the communitor. The primary treatment effluent samples were taken from the effluent channel of one of the plant's two primary clarifiers. The secondary treatment samples were taken from the effluent channel of one of the two secondary clarifiers at the plant, which follow after the trickling filters. The final treatment samples were taken from the effluent channel of one of the three final clarifiers at the plant, which follow the activated

[57] *Photomultiplier Tube (PMT).*

sludge system. Finally, the effluent samples were taken as the flow passes over a weir at the end of the chlorine contact chamber, immediately after chlorination & dechlorination, just before the flow enters the outfall pipe leading to the Otter River. Photographs of the sampling from each process can be seen below in Figures 18 - 22.

Figure 19: Location of influent sampling

Figure 20: Location of primary clarifier sampling

Figure 21: Location of intermediate clarifier sampling

Figure 22: Location of final clarifier sampling

Figure 23: Location of effluent sampling

The easiest and most practical way to collect samples for this project was to use grab samples from each point in the plant. Grab samples are defined by the *Standard Methods for the Examination of Water & Wastewater* as, "single samples collected at a specific site over a short period of time (typically seconds or minutes."[58] Thus, grab samples only represent the composition of the source at a specific time and place. When a source is known to be relatively constant in composition over time and in all directions, grab samples are representative of longer periods of time. Although wastewater flows typically fluctuate throughout a 24-hour period, each set of samples from the plant was taken at the same time, so for the purposes of showing copper removal grab samples were sufficient. Sampling itself took place during six trips to the Gardner WWTF. The samples were collected with a long-handled dipper, as can be seen below in Figure 24. Before taking a sample at each step, the dipper was rinsed in the water at each step to eliminate any false readings due to residual water from prior sampling. Each sample was then poured from the dipper into plastic 250 ml sampling bottles, as can be seen below in Figure 25. Each bottle was labeled with the date, advisor's initials, the Gardner WWTF and the location of the sample within the plant. After collection, the samples were stored in a cooler for transport back to WPI. Once back at WPI, the samples were taken to the Environmental Laboratory in Kaven Hall, where 3-5 drops of 10% hydrochloric acid (HCl) solution were added to neutralize organic growth in the bottles. The samples were then stored in the refrigerator until needed.

[58] Greenberg et al, p. 1-29

Figure 24: Grab sampling using long-handled dipper

Figure 25: Picture of 250-mL sampling bottle

Before testing could begin using the AA machine, the samples had to be prepared. Since the machine tests for metals in solution, it was important to ensure the solids content in the test samples was virtually zero. The wastewater was being tested for both total and dissolved copper, so it was necessary to prepare two test samples from each sample taken at the plant. For the dissolved copper testing, the plant samples were simply filtered to remove all solid particle matter, thus leaving only dissolved copper for testing. The filters used for this step had a pore size of 0.45 µm. They were Millipore Non-sterile Millex filter units, with diameters of 33 mm. These filters have a male Luer-Lock tip that can be used with any brand syringe with a female Luer-Lock tip. Standard 20-ml syringes were used in conjunction with the filter units to prepare the samples. The procedure for filtering the sample wastewater is as follows: shake the sample bottle well to disperse all solids, draw approximately 25 ml of sample into the syringe, attach the filter to the syringe tip, and push the sample through the filter into

a centrifuge tube, as seen below in Figure 26. Once the samples were prepared, labels identifying the project and the sample were affixed to the centrifuge tubes and the tubes were then placed in the AA room of the WPI Environmental Laboratory for testing with the machine.

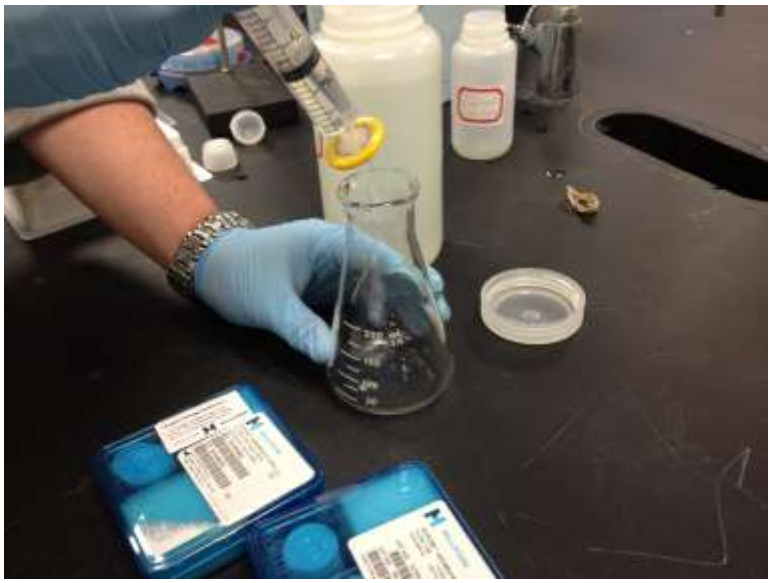


Figure 26: Filtration using 0.45 µm filter

In order to test for total copper using the AA machine, the solids had to become dissolved in the solution before the machine could be used. The preparation for the total copper analysis consisted of digesting the samples to absorb the solid copper in solution. To prepare the samples for digestion, 50 ml of sample was drawn from the sampling bottles using a volumetric flask. The flask was cleaned before use, and then washed out three times with the sample being tested to ensure there was no leftover copper from prior samples in the flask. The sample was then poured into a 250 ml Erlenmeyer flask. Then, 2.5 ml of nitric acid was added to the flask before it was heated on a hot plate until the 50 ml of solution digested down to 25 ml, which took about 2 hours on average. This is illustrated in Figure 27. After this, the samples needed no further preparation and were tested using the AA machine.

Figure 27: Using hot plate to digest sample for testing

To avoid overloading the machine, for samples predicted to have high copper content, mainly the influent samples, the AA flame was first used, and if more precision was necessary the samples were retested using the AA furnace. Once AA testing had begun, a small amount of each prepared sample was drawn and put in a vial which was then placed in a certain spot on the AA machine's turntable. The machine uses a straw to extract sample, and only drew about 15 µl of sample for each trial. The reason that so little sample was used in each test is that copper is a very reactive metal and much more sample would overload the AA machine. After the tests were completed, a printout was made containing a calibration curve and all test results.

3.2 Sampling at Other WWTFs

In order to confirm that the pattern observed at the Gardner WWTF is common among other plants in the area, samples were taken from three other area WWTFs and analyzed for total and dissolved copper in the lab at WPI. To ensure that most of the copper was being removed after primary treatment, the group decided to retrieve influent samples, samples after primary treatment and effluent samples from the area plants. After getting in touch with several plants in central Massachusetts, the group ultimately decided to take samples from the Leominster Water Pollution Control Facility in Leominster, MA, the Marlborough-Westerly Wastewater Treatment Plant in Marlborough, MA and the Upper Blackstone Water Pollution Abatement District's plant located in Millbury, MA. Leominster was selected due to its proximity to Gardner. Marlborough-Westerly was chosen because the plant is currently undergoing a major upgrade. The Upper Blackstone plant was selected because it treats all of the wastewater from the city of Worcester and it surrounding towns, and there is much industrial activity within those jurisdictions.

The procedure for carrying out the sampling at other local WWTFs was virtually identical to the procedure for the plant sampling routine. The samples were collected using grab samples, stored in

plastic sampling bottles & brought back to WPI's lab. There, HCl was added to eliminate any biological growth, and the samples were tested for both total and dissolved copper using the AA machine. The samples were prepared and testing following the same procedures as above.

In addition to determining a trend in copper removal, this task gained another objective later in the project. There is currently a working sand filter at the Milford WWTF located Hopedale, MA and serving the Town of Milford. It was reported that this sand filter may be removing significant amounts of copper from the plant's flow. The group decided to sample the influent and effluent flows from the filter to determine what, if any, copper removal was taking place. The group drove to Milford and took grab samples before and after the sand filter. They were then returned to WPI and tested as above, using AA and testing for both total and dissolved copper.

3.3 Filtration Experiment

In addition to identifying copper removal in the Gardner WWTF, an experiment was conducted in which the group attempted to identify a relationship between solid particle size and total copper concentration. This experiment was carried out in the hopes that the results would show that copper removal is possible by removing particles of a certain size, and a filter could then be designed for the Gardner plant. In almost all wastewater treatment plants that employ the use of filtration as a means of tertiary treatment, the filtration units come after the biological treatment and before disinfection of the flow. Knowing this, these tests were carried out using final clarifier effluent from the Gardner WWTF. As with the plant sampling routine, grab samples were taken using the long-handled dipper and a 1000 ml plastic sampling bottle to store the sample. The samples were marked, treated with hydrochloric acid and stored in the same fashion as the samples from the above procedure. For this test, it was only necessary to measure total copper, as dissolved copper cannot be removed through traditional filtration methods.

After looking at different pore size filters, the group decided to filter the final clarifier effluent through three different filters, with pore sizes of 1.2 µm, 5.0 µm and 10.0 µm. Millipore Swinnex 25 mm filter holders were used for this experiment. The filters themselves were Millipore Isopore polycarbonate membrane filters. To fit the filter holders, 25 mm diameter filter discs were used. To set up the filter and filter holders, it was necessary to insert the filter disc along with a rubber washer in between the two pieces of the holder and then screw the holder together, forming a tight seal so no water leaked through. The procedure for filtering the samples is as follows: first, shake the sampling bottle well to evenly disperse all particulate matter, draw 20 ml of sample into the syringe, attach the assembled filter and filter holder, push the sample through the filter into a 250 ml Erlenmeyer flask. The procedure had to be repeated twice more for each sample, drawing 20 ml the second time and 10 ml the third time, to ensure that there was 50 ml of filtered sample in the flask when finished. Because testing for total copper was done using the AA machine, the filtered sample had to then be digested, so 2.5 ml of nitric acid was added to the flasks and they were heated on the hot plate until the volume of sample decreased to 25 ml. The samples were then ready to be analyzed using the AA machine, as in the plant sampling testing. Printouts were created showing the calibration curve and all results after each round of testing. In order to ensure consistency in our results, the filtration tests were repeated

three times during late January and early February. A visual of this experiment being done is shown in Figure 28.

Figure 28: Filtration experiment testing

3.4 Chemical Precipitation

After review of the results of the plant sampling routine and the filtration experiment, a brief experiment was conducted to analyze the potential for using chemical precipitation as a means of copper removal. This experiment was carried out to identify if it was possible to precipitate copper out of the final clarifier effluent at the Gardner WWTF. In order to examine the possibilities of achieving positive results using the low concentrations of copper at the Gardner WWTF, two control experiments were first carried out. The first was done by dissolving 3.3479 grams of copper tubing in 100 ml of deionized water using 10 ml of nitric acid, to achieve a copper concentration of 3,347.9 parts per million (ppm). The intent of this test was to visually demonstrate to the group the effects of chemical precipitation on a larger scale and to allow a good visual of flocculation and settling of copper out of the solution. Figure 29 shows how the copper tubing was dissolved into solution. The second test was carried out using 100 ml of a sample with a known copper concentration of 10 ppm. This test was done to see if chemical precipitation was possible with lower copper concentrations.

Figure 29: Dissolving copper tubing into solution

The procedure for carrying out the precipitation experiment involved two main parts: raising the pH of the solution and letting the flocs created settle to the bottom of the sample. The samples were placed into 150-ml beakers for testing. The beaker was placed on a magnetic stirrer and a stir bar was dropped to the bottom of the beaker to ensure mixing of the solution. A pH probe was then placed in the solution to measure the pH as the chemical was added. The chemical selected for use in this experiment was sodium hydroxide, NaOH. Due to the low concentrations of copper in the samples, a low concentration of NaOH, 0.25%, was used. Once the pH probe was in place and stirrer turned on the test could begin. Drops of 0.25% NaOH were added one-by-one until the pH of the solution stabilized around 8.5. Once this occurred, no more drops were added and the solution was left, with the stirrer on, for about 10 minutes. Figure 30 below shows the setup for testing using the 10 ppm sample. Once the 10 minutes was up, the stirrer was turned off and the beaker was left overnight in the lab for settling to occur. The next day, 25 ml of the solution was drawn using a transfer pipette and placed in a labeled centrifuge tube and placed in the AA room for testing using the AA machine.

Figure 30: Setup of chemical precipitation experiment

Once the results of the two preliminary tests were obtained and they showed success, the group moved ahead and conducted the same experiment on wastewater from the Gardner WWTF. It was decided to use final clarifier effluent for this experiment, as any new treatment system would likely be installed between the existing final clarifiers and disinfection. The samples were collected as in all the other experiments, using a long-handled dipper and 1000-ml sampling bottle, and they were brought back to WPI's lab where HCl was added before storage in the refrigerator. The same procedure as was used above was carried out on the Gardner plant water to perform the experiment.

3.5 Hardness Testing

Water hardness is an important parameter used to ensure good water quality. Hardness is a measure of the quantity of divalent ions in water. The ions measured for hardness are salts. Since calcium and magnesium are the most common sources of water hardness, hardness tests seeks to measure the amount of calcium and magnesium present in a sample. Hardness is measured through chemical titration, and is reported as the quantity (mg/l) of calcium carbonate ($CaCO_3$).[59] The health of aquatic life in receiving streams can be negatively affected by very low concentrations of metals present in those waters. The EPA is therefore required to limit pollutants which can harm resident aquatic life in receiving streams. According to the EPA's Office of Water – Office of Science and Technology, "The hardness of the water containing the discharged toxic metal should be used for determining the applicable criterion."[60] In this instance the criterion is hardness, and the water containing the discharged toxic metals is the downstream hardness from where the Gardner WWTF's outfall is located. After review of the permit documents regarding the Gardner WWTF, and after contact with MassDEP

[59] Wurts.
[60] NPDES Permit No. MA0100994 Fact Sheet, p. 7

and city of Gardner officials, it was determined to replicate the hardness calculation found in the permit, as well as test the hardness just downstream of the plant.

The purpose of testing the hardness of the Otter River is to determine if the city should contact the EPA and MassDEP for a site-specific evaluation of the plant in the Otter River. As the concentration of $CaCO_3$ in a water body rises, the limits on metals become less restrictive. In order to perform hardness testing, the group first had to examine how the EPA calculated the hardness values in the current NPDES permit in order to replicate those tests. The EPA calculation yields the combined in-stream hardness of the water body, which is the calculated downstream hardness using the upstream flow and the plant effluent flow. This equation can be seen below.

$$[(Q_{WWTP} * C_{WWTP}) + (Q_R + C_R)]/(Q_{WWTP} + Q_R) = C$$

where:

Q_{WWTP} = *Design flow of Gardner WWTF*
C_{WWTP} = *$CaCO_3$ concentration for the Gardner WWTF*
Q_R = *7Q10 flow of the Otter River*
C_R = *In-stream $CaCO_3$ concentration*
C = *Combined $CaCO_3$ concentration*

Using this equation, it became clear to the group that samples would need to be collected to determine the upstream hardness and the hardness of the plant effluent. It was also decided to collect a sample of downstream hardness to compare against the result of the EPA calculation. A trip was made to the Gardner WWTF in late March to collect the samples. The effluent sample was taken like the effluent samples in the plant sampling routine, at the end of the chlorine contact tank, using a long-handled dipper. The upstream sample was taken where MA Route 2A, West Broadway in Gardner, crosses the Otter River south of the plant, and the downstream sample was taken where MA-101, Gardner Rd crosses the river, just north of the plant and just east of its intersection with Plant Road. Figure 31 below shows the locations where the samples were taken relative to the plant. The samples were collected using a 5-gallon bucket with about 20’ of rope tied to its handle. The bucket was thrown down into the river from atop the overpasses, filled with river water, and hauled up. A labeled 250-ml water sampling bottle was then dipped in the bucket to collect the sample. Figure 32 below shows the procedure for collecting the samples from the Otter River. After the samples were collected, they were returned to WPI and stored in the Environmental Laboratory until testing occurred. Unlike the samples taken for other experiments, no HCl was added to these samples in order to avoid skewing the results of the testing.

Figure 31: Using 5-gallon bucket to collect river samples

Figure 32: Locations of sampling for hardness test

Image courtesy of Google Earth

After discussion with Don Pellegrino and Professor Paul Mathisen of WPI's Department of Civil and Environmental Engineering, the group decided to use a drop-count titration test kit to perform the hardness testing. The kit, manufactured by the Hach Company, is Model HA-71A, total hardness test kit. This test kit allows for determining low-range hardness between 1-20 mg/l and higher range hardness between 20-400 mg/l. It was selected because it includes all necessary reagents to perform the test, the drop-count titration method is relatively simple, and it can report a wide range of hardness values.

Following the instructions provided with the kit, the group carried out the hardness testing. A demonstration of this test is seen below in Figure 33.

Figure 33: Hardness test in progress

3.6 Industrial Survey

In addition to the many laboratory tests conducted, the group also produced an extensive survey to distribute to selected industrial users connected to Gardner's sewer system in an attempt to identify if any users are discharging high concentrations of copper into the city's sewer system. Once the surveys are returned to the city and the results are examined, further sampling of the sewer system around such sites may be necessary to determine approximate levels of copper discharge from these users.

To better understand the industrial processes in Gardner and what was being discharged from the local industries into the sewers a questionnaire was developed and distributed to a number of those local industries. Research was conducted on other similar surveys that had been distributed in other cities and towns in the United States concerning wastewater and industrial discharge into the sewage system. Referencing previous studies done in other parts of the country like the **General Questionnaire for Effluent Treatment** done by **Industrial Waste Water Services, LLC** allowed for an overview of what the questionnaire or survey should look like.

Although most other surveys were far too in depth and had many questions inquiring information that was not necessary for the situation in Gardner, the previous surveys were a great help in guiding how our questionnaire should be developed. After some careful consideration a seventeen question survey was developed for the city of Gardner and some of its industries. The survey was not distributed to every industry in the city of Gardner, but rather to industries that would have the potential of using copper or other metals in their processes. For example, the survey may not have been sent to a company producing a food product, but was distributed to a metal manufacturing or printing company. Questions on the survey were developed to focus on copper in the process, the quantity of total discharge and how often wastewater was discharged into the sewage system. Also, the survey

inquired as to whether the industries performed any pretreatment prior to discharge into the sewage system. The survey is located in Appendix B of this report.

Chapter 4: Findings

The following chapter of this report describes the results of the many tests in the methodology section. These tests were completed entirely by the group, with the exception of using the AA machine. This sections demonstrates

4.1 Plant Sampling Routine

Samples were collected throughout the treatment system at five locations. These locations are: influent, primary clarifier, intermediate clarifier, final clarifier, and effluent. The most important results of these tests would be the copper effluent levels, since that copper level represents the amount of copper entering the Otter River from the Gardner WWTF. Of six trials conducted, only one was within the EPA discharge limit of 13.6 ppb, as shown in Figure 34 below. The other trials indicate a copper discharge level far greater than the EPA limit, although many of the samples taken were grab samples. This sampling routine proved successful at demonstrating the Gardner WWTFs current copper removal. In its current stat, the plant removes approximately 70% of the copper present in its influent flow before discharge into the Otter River, all done without any copper-specific treatment. As can be seen below in Figure 35, the average influent total copper concentration over the six trips to the plant was 79.21 ppb, the average effluent total copper concentration was 23.15 ppb. This discharge concentration is still higher than the permitted limit of the plant, but that can be attributed to the use of grab samples as opposed to 24-hour composite samples, which are required by the permit. The grab samples represent only one specific instance in time, and many of the group's trips to the plant occurred during daily lower flow conditions, and many of them took place during a winter which saw almost no precipitation.

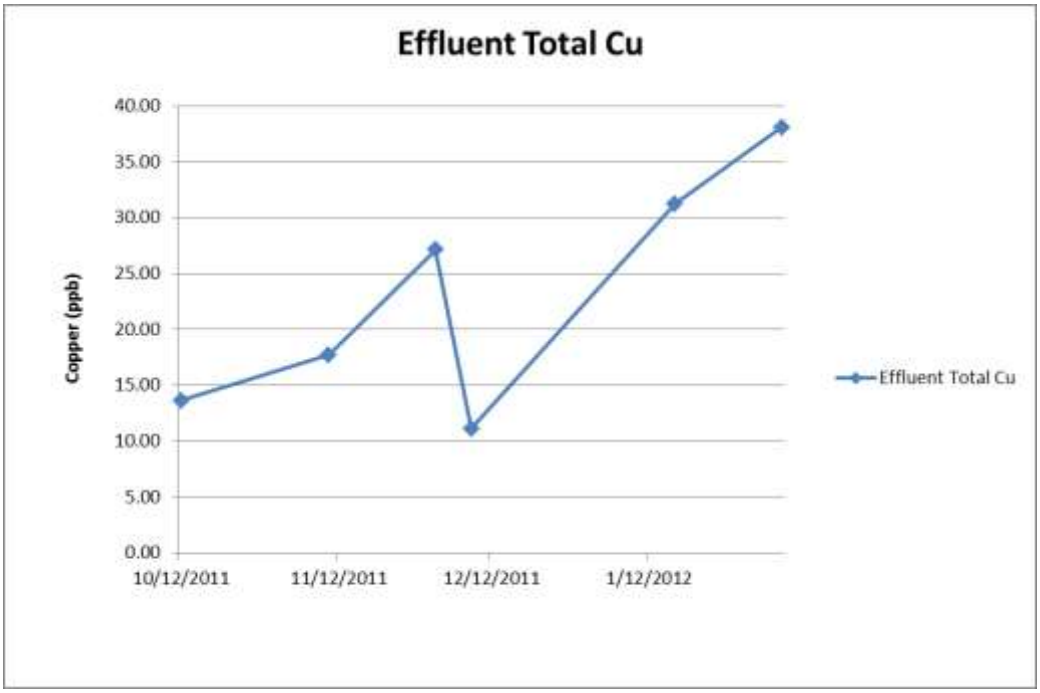


Figure 34: Total copper effluent concentrations from 6 trials

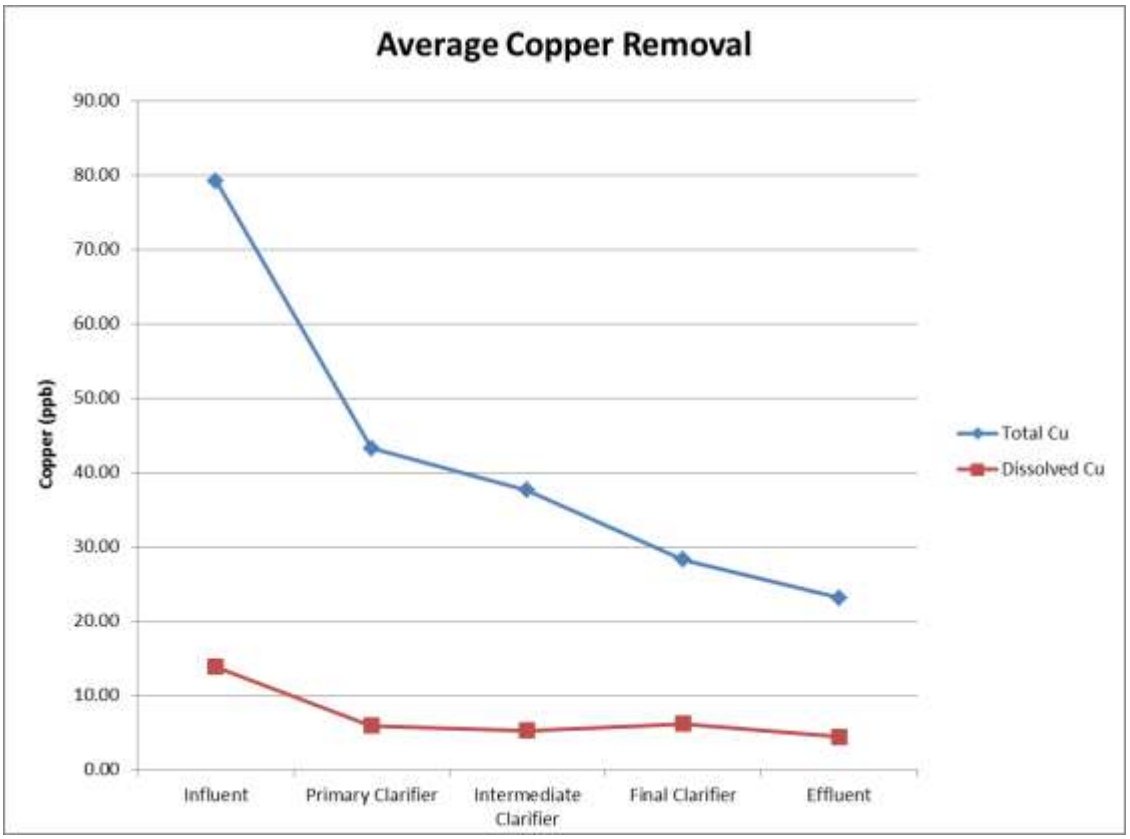


Figure 35: Average results of plant sampling routine

Past studies have shown that the additional flow provided by rainfall has helped in achieving copper limits within the EPA standards. The extra rainfall will increase the infiltration and inflow of the plant influent, diluting the copper more than average daily flow. This trend can be seen in the Maguire study shown below, where the copper levels (taken by composite sampling) are reduced during the months with heavy rainfall.

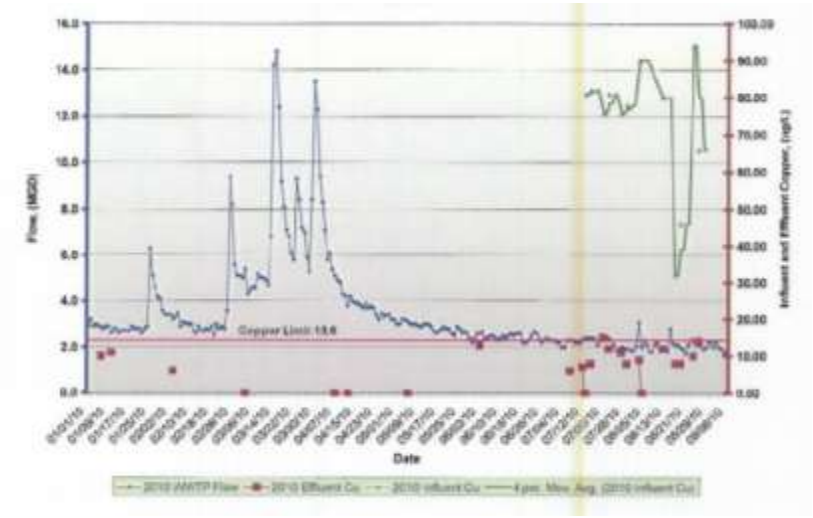


Figure 36: Copper concentrations from previous Maguire study

Another important finding to note is that overall, the dissolved copper levels existing in the plant are well below the NPDES permit discharge limit. The dissolved copper levels are not putting the plant in violation of its NPDES permit. The total copper levels are the problem. This can be seen above in Figure 35 and below in Figure 37. Removal of dissolved copper, which is more difficult and costly to do than total copper, is not the recommended approach to take in helping the plant meet its discharge limit. The total copper on the other hand, is where all efforts to remove copper concentrations should primarily be focused. The remaining tests conducted for this project all follow upon this conclusion, and all are aimed first at removing total copper from the plant flow.

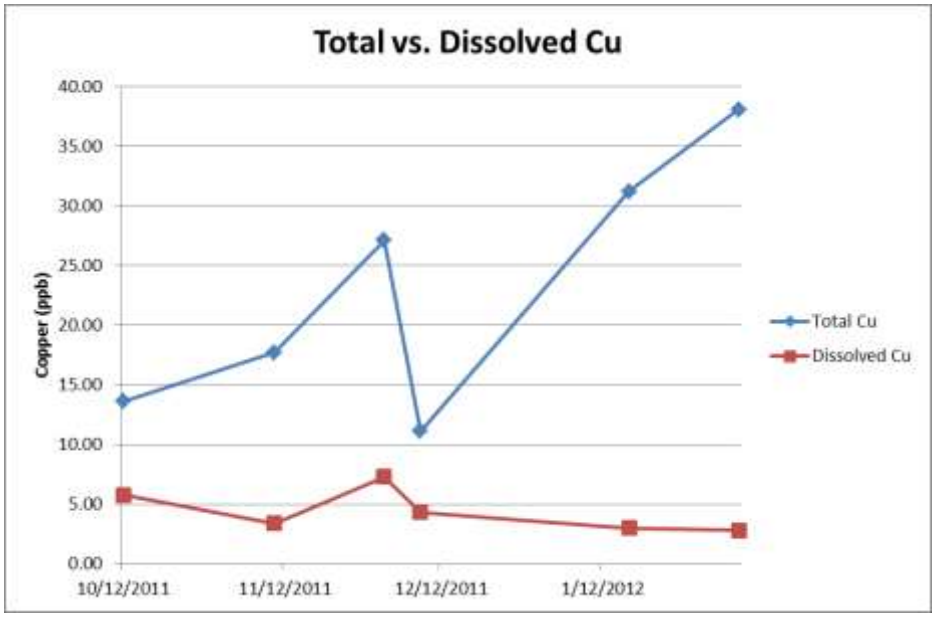


Figure 37: Total vs. dissolved copper levels over the 6 trials

4.2 Filtration Experiment

The filtration experiment was carried out after the results of the plant sampling routine were determined and a pattern was established showing copper removal within the Gardner WWTF. Unfortunately, the results of this test proved to be inconclusive. If the results were as expected, the smaller pore size filters should have corresponded with lower concentrations of total copper in the sample. The results of the test carried out by the group did not show this expected trend. The average unfiltered copper concentrations had the lowest values at 24.2 ppb, which was not at all what was expected. The 5 µm filter yielded a lower value than the 10 µm value which shows some removal, but it is also lower than the 1.2 µm filter. This shows inconsistent results. The copper concentrations also varied tremendously throughout the three trials, as can be seen below in Table 8. Figure 38 shows the average results of the filtration experiment.

Table 8: Filtration experiment results

Filter Size (µm)	Copper (ppb)		
	Trial 1	Trial 2	Trial 3
0.45	34.68	31.92	
1.2	44.77	40.62	22.59
5	44.67	29.82	16.40
10	57.17	35.69	19.36

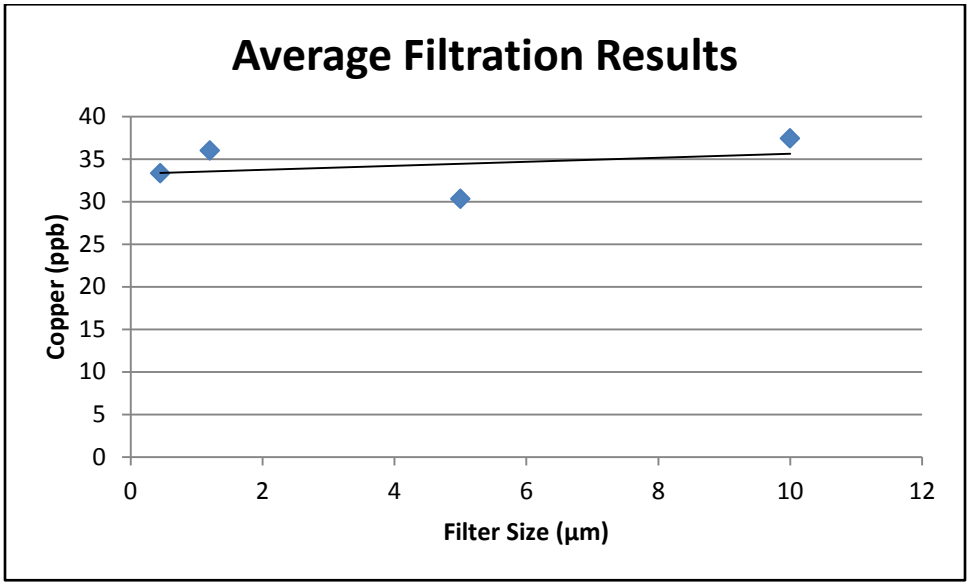


Figure 38: Average filtration results

As can be seen from the table and figure above, no concrete conclusion regarding copper removal through smaller and smaller filter sizes can be made. Although the trend line in Figure 38 has a negative slope as pore size decreases (moves from right to left), only the 10 µm and 0.45 µm results come near to the line. The 5 µm filter shows the lowest average copper concentration, while the 1.2 µm

filter shows the second highest. A successful experiment would have each smaller filter size showing a corresponding decrease in copper concentration. Ideally each point on the graph would have been on the trend line.

This experiment is a good example of how the limitations of the testing apparatus can have an effect on the results. The AA machine at WPI was only drawing 15 µl of sample for each test, a very small amount of sample. The variations in copper concentration, even in a sample of only 25 ml, can be substantial with such a small amount being drawn for testing. The reason the machine could only draw so little is that there was a risk of overloading the machine if too much copper was used. After speaking with Don Pellegrino, the lab manager, it was determined that at on this machine, values of copper concentration within 10 – 15 ppb of one another constitute about the same value because of the limitations on the testing accuracy. Therefore, it can also be concluded that all the values for copper above may also be the same. This conclusion also supports the finding that the results of this test are inconclusive.

4.3 Chemical Precipitation

With the results of the filtration experiment proving to be inconclusive for removing total copper, a chemical precipitation experiment was considered for removal of both total & dissolved copper from the Gardner WWTF flow. This test was carried out using final clarifier effluent from the plant, and using sodium hydroxide (NaOH), as the chemical additive for flocculation.

The first control experiment, using the dissolved copper tubing, proved to be successful. Once the tubing was dissolved in the solution and the test was begun, immediate results could be seen. Large flocs formed almost as soon as any NaOH was added to the solution. The degree of flocculation was so large that the sample had to be moved to a larger volume flask twice because the solids that quickly settled out paralyzed the magnetic stir bar, stopping any mixing from occurring. This test eventually has to be stopped as there was no larger containers to use that would allow for adequate mixing. The copper concentration of the sample was not analyzed after this test, as its primary purpose was to demonstrate the mechanisms of chemical precipitation, flocculation, and settling. This test was successful as it showed, on a large scale, how chemical precipitation works, and showed the group things to look for in carrying out further tests. Figure 39 shows the results of this test, after the sample had been moved to a 2000 mL volumetric flask and left to settle overnight in the lab. The denser blue material on the bottom of the flask is the flocs created by the NaOH after they have settled, and the blue hue of the remaining solution suggests that there is still copper dissolved in the water.

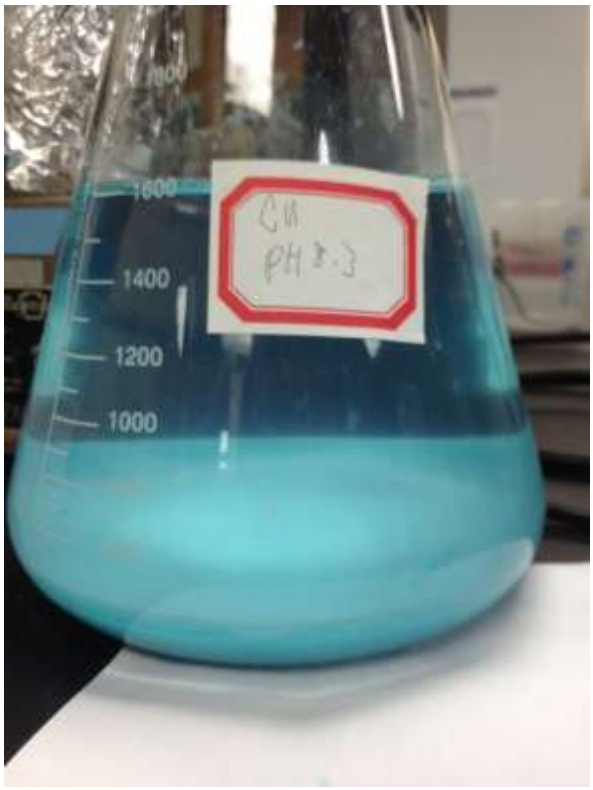


Figure 39: Results of precipitation of dissolved copper tubing

The next preliminary test, which used the known 10 ppm concentration of copper, was then conducted. Unlike the previous test, such immediate and noticeable results were not seen. The sample was raised to a pH of 8.5, and then was allowed to mix for a full 10 minutes before settling began. After the stirrer was turned off, some brown particulate matter, which the group thought was iron, had settled to the bottom of the beaker. This can be seen below in Figure 40.

Figure 40: 10 ppm precipitation test after mixing

After being let to sit overnight, the samples were tested for copper using the AA machine. The results showed an 89% removal of copper. The initial 10 ppm concentration was reduced to 1.1 ppm in the sample. This test also proved successful, showing that copper removal via precipitation can happen in smaller concentrations. The results of this test are shown below in Figure YY. Even though this test was successful, it was still not known if chemical precipitation would work on the plant water in Gardner, which had copper concentrations almost 1000 times less than the 10 ppm sample.

After the preliminary tests were finishes, a precipitation test was carried out on one sample of plant water. Only one sample was tested due to the time constraints of the project. The initial concentration of total copper from the final clarifier effluent was 23.82 ppb. After raising the pH to 8.5, mixing, and allowing settling to take place overnight, the sample was then tested again. The measured copper level taken from the sample the next day was 8.14 ppb. This shows a 65.2% reduction in copper as a result of chemical precipitation at pH 8.5 using NaOH. The results of the test are shown visually below in Figure 41.

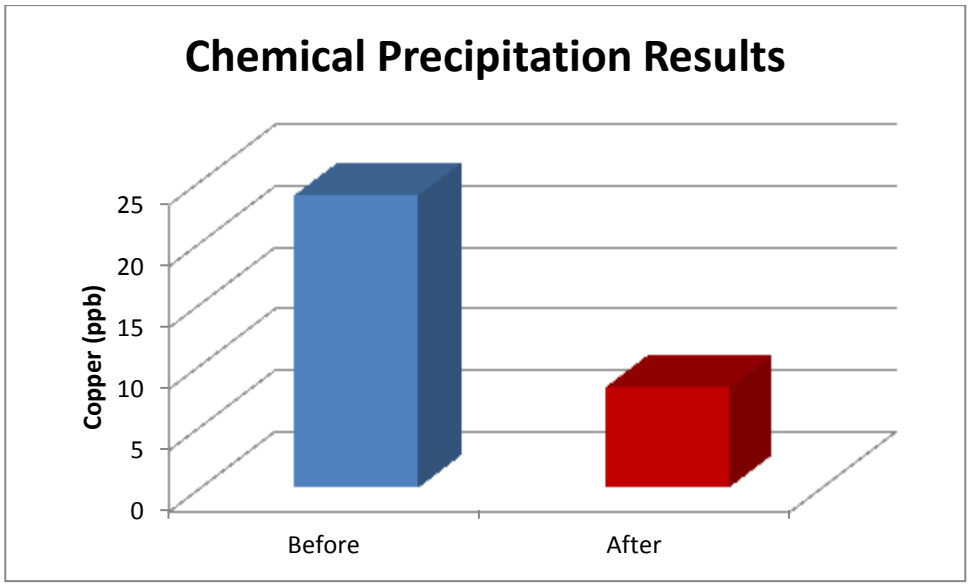


Figure 41: Results of precipitation experiment on plant water

Chemical precipitation using NaOH, at room temperature and pH of 8.5, proved to be a useful method in removing copper from the flow in the Gardner WWTF. Although this test was only conducted once using plant water, the results of the preliminary tests and the test on the plant sample are consistent with one another. Although this experiment shows success, it should be noted that as in the filtration experiment, there may be a range of values as high as 10- 15 ppb above or below the reported value that could be the actual value. This is important to note because this test reduced the copper concentration of the final clarifier effluent by 15.68 ppb. More tests would have to be conducted to ensure the values are consistent with one another.

There are also several considerations that must be taken into account in evaluating the usefulness of chemical precipitation in the Gardner WWTF. Additional batch reactors would likely have to be constructed, along with additional settling tanks or a filtration system, either a membrane filter or sand filter. Additionally, because this test alters the pH of the water, the pH would have to be lowered to match the natural pH of the Otter River before discharge, adding another unit to the process. It is also unknown what effect(s), if any, raising and lowering the pH and adding NaOH to the flow would have on other flow characteristics that are also monitored and controlled by the EPA and NPDES.

4.4 Hardness Testing

The hardness testing conducted by the group showed mixed results. After performing the drop-count titration test on the samples, and calculating the result in mg/l as $CaCO_3$, the results of the ten trials for upstream, downstream and plant effluent were tabulated and average values for each were determined to be used in replicating the EPA's calculations. Table 9 below shows the results of each of the trials and the calculated average values.

Table 9: Results of hardness testing

Trial	Effluent Hardness (mg/L as CaCO3)	Upstream Hardness (mg/L as CaCO3)	Downstream Hardness (mg/L as CaCO3)
1	290.7	51.3	68.4
2	239.4	34.2	85.5
3	239.4	34.2	68.4
4	239.4	34.2	51.3
5	222.3	34.2	51.3
6	239.4	34.2	68.4
7	222.3	34.2	51.3
8	239.4	34.2	51.3
9	239.4	34.2	51.3
10	222.3	34.2	51.3
Average	**239.4**	**35.91**	**59.85**

As can be seen in the table above, after 10 trials using drop-count titration, the average hardness of the plant effluent is 239.4 mg/l as $CaCO_3$, the average hardness upstream of the plant is 35.91 mg/l as $CaCO_3$, and the average hardness downstream of the plant is 59.85 mg/l as $CaCO_3$. The EPA values used in the calculation were 168 mg/L as $CaCO_3$ for the plant effluent and 23 mg/L as $CaCO_3$ upstream of the plant. The 7Q10 flow of the Otter River, obtained from a nearby USGS station (01162900) and accounting for runoff nearby, was 2.9 cubic feet per second (cfs). The design flow of the plant is 5.0 MGD, alternatively expressed as 7.74 cfs. The results of the EPA calculation for hardness

showed a combined in-stream concentration of 129 mg/L as $CaCO_3$ for hardness. Using the same values for the plant design flow and the 7Q10 flow of the Otter River, the group's calculation of hardness is as follows:

$$Q_{WWTP} = 7.74\ cfs$$
$$C_{WWTP} = 239.4\ mg/L$$
$$Q_R = 2.9\ cfs$$
$$C_R = 35.91\ mg/L$$

$$[(7.74\ cfs * 239.4\ mg/L) + (2.9\ cfs * 35.91\ mg/L)]/(7.74\ cfs + 2.9\ cfs) = 183.9\ mg/L$$

This calculated value for in-stream hardness is higher than what the EPA calculated, thus leading the group to consider that the discharge limits for metals could be raised. However, the downstream sample showed a hardness of 59.85 mg/L as $CaCO_3$. This value is much lower than both what the EPA and the group each calculated. Because of this, the group cannot definitively say that the hardness of the Otter River is high enough to push the EPA to recalculate and possibly raise metals limits, because it could result in lowering the limits. The results of the group's testing and the EPA testing probably vary because of the accuracy of testing performed by each. The EPA has more accurate methods of measuring hardness than a simple drop-count titration. The EPA most likely used a more complex test method with far more accurate results.

4.5 Regional WWTF Sampling

Other WWTF in the surrounding area of Gardner were also tested for copper levels. Samples were taken from the Marlborough-Westerly plant, Leominster plant, and Upper Blackstone plant. Water samples were collected and compared at the influent, primary clarifier, and effluent, with the exception of Leominster, which did not submit a sample from the primary clarifier. Below are graphs that display the total copper levels and dissolved copper levels of the surrounding WWTFs.

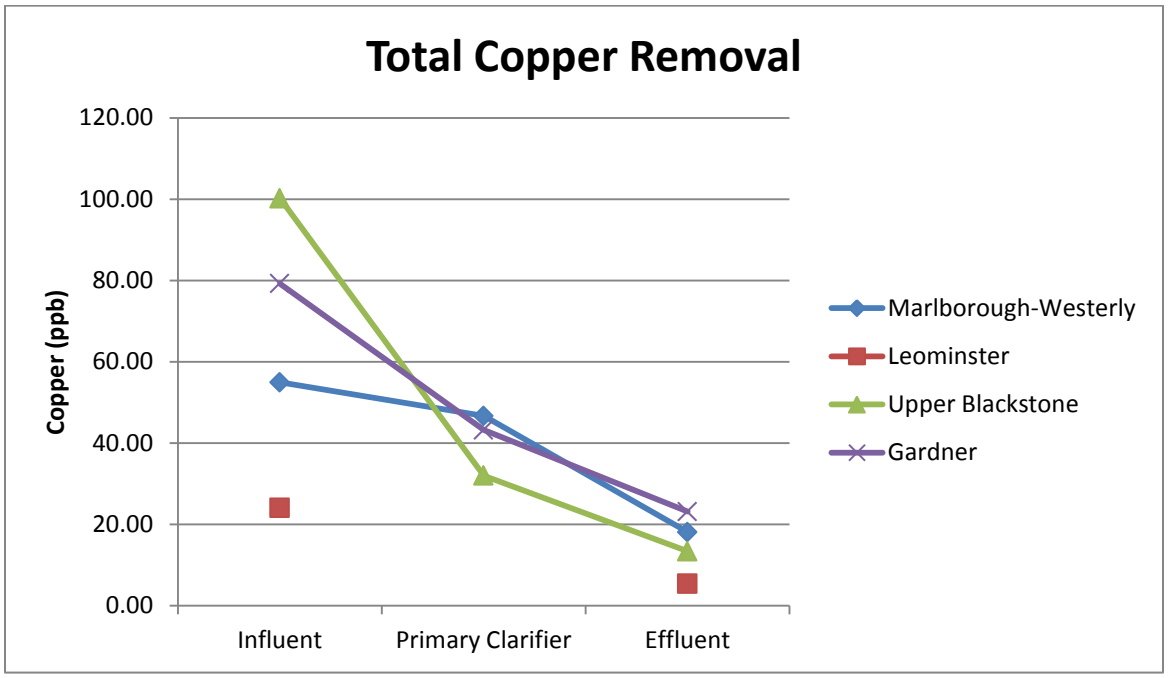


Figure 42: Total copper removal from other WWTFs

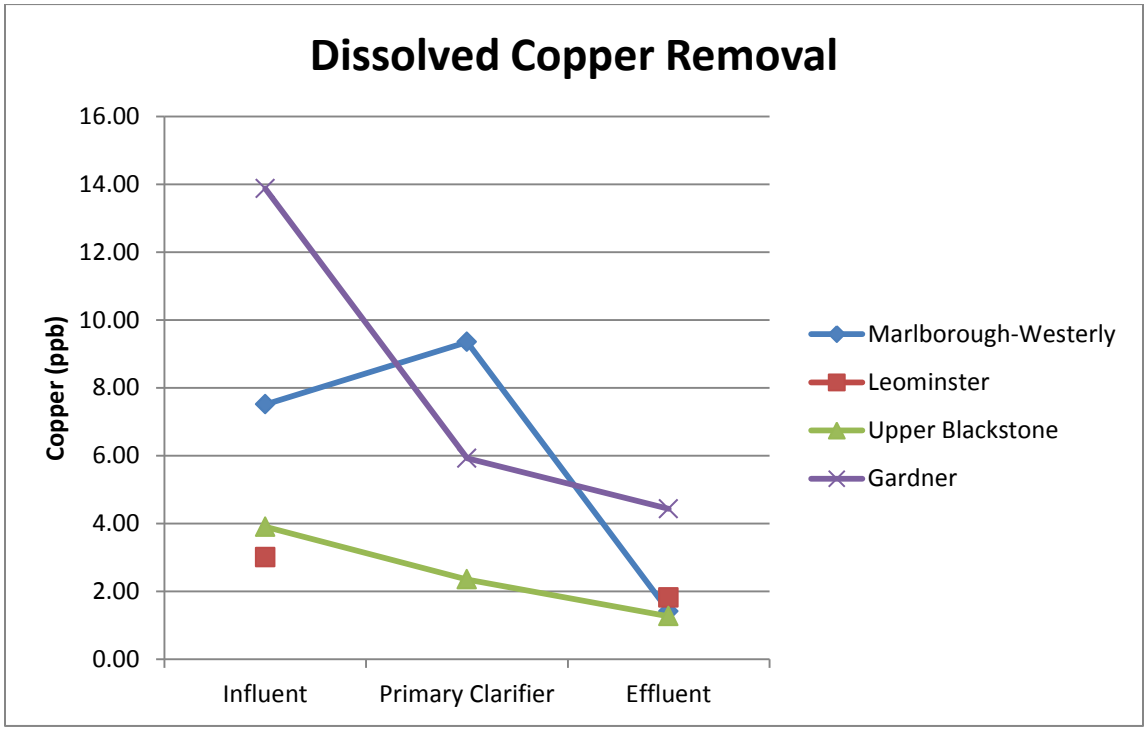


Figure 43: Dissolved copper removal from other WWTFs

Leominster had an extremely low influent copper level of 24.05 ppb, and discharged at 5.43 ppb. Leominster also had low dissolved copper levels entering and exiting the plant at 3.01 ppb and 1.82 ppb respectively. Marlborough-Westerly (MW) also had low total copper levels in comparison to Gardner. MW's influent copper level measured at 54.96 ppb, which was reduced to 18.11 ppb. Their dissolved copper was also significantly reduced from 7.51 ppb to 1.42 ppb. Upper Blackstone saw the most drastic reduction in total copper from 100.2 ppb to 13.41 ppb, and a dissolved copper reduction from 3.91 ppb to 1.27 ppb. The Gardner WWTF was graphed as a control to see if Gardner's copper levels are similar to those of other plants in the region. The Gardner WWTF had similar trends to the other WWTFs, although Gardner's copper reduction was not as high as the others.

Results from the test of the sand filter at the Milford WWTF indicate no influence on copper removal. The total copper concentration of the filter influent is 24.10 ppb, and effluent total copper concentration is also 24.10 ppb. Although the sand filter's primary use is to stop large pathogens from entering the Ultra Violet treatment stage, the filter should also be able to stop copper. Unfortunately, only one test was conducted using this sand filter where more tests are necessary to conclude that the sand filter is not capable of removing copper from wastewater.

Chapter 5: Recommendations

The group is proposing several recommendations to the city of Gardner after completion and review of all experiments and findings detailed in this report. These recommendations are intended as possible next steps to be considered by the city in its efforts to more consistently meet its copper discharge limit. The recommendations focus on treatment options, further studies, and management implementations to be incorporated into the plant with upcoming renovations planned by the city.

5.1 Source Studies

The first and foremost recommendation from the group to the Gardner Department of Public Works is to continue work on surveying city industries. A more comprehensive study must be carried out to attempt to identify any major contributors of copper into the city sewer system. While the results from the survey sent out by the group do not point to any one industry as a significant contributor of copper to the sewer system, another study is still recommended. The group's survey made it explicitly clear that its purpose was for an academic project, which does not carry much weight with many business owners, especially if they fear they may be in violation of the city's sewer ordinance. If the city and/or its agent or representative sent out another survey, stating that follow up testing will be conducted at suspected problem sites, business owners may be more inclined to be totally forthcoming about their processes and chemicals used, etc. The city is encouraged to not only survey potential high dischargers, but to go out in the field and test sewer flows upstream and downstream of those users' discharge points. Once the results of any surveying and/or testing are known, it is recommended that the city compare those to its copper discharge limit of 300 ppm specified in its sewer ordinance. If any users are found to be in violation of the ordinance, they city should take enforcement action on them. City officials may also want to expand such a program to sample residential areas or other large dischargers, such as the Town of Ashburnham or the North Central Correctional Institution. Such expansion of the program is also recommended, if the city wishes to do so.

The group strongly encourages the city to initiate a source study before any additional treatment methods are considered. Undertaking such a study has several benefits. First and foremost, the cost to carry out a survey and sampling routine with lab testing is much less than the capital cost and life-cycle costs associated with additional treatment systems at the WWTF. Also, if any user is found to be in violation of the ordinance, it is their responsibility to meet the limit, not the city's. Users would become responsible for designing and implementing pretreatment systems to meet the sewer ordinance discharge limit. The responsibility of the city would be reduced to testing the effluent; no capital costs or other risks would have to be assumed by the city. Additionally, conducting a source study of studies shows that the city is being proactive in its attempts to reduce copper levels in the WWTF. This could buy the city more time from the EPA and MassDEP before more stringent limits are imposed or fines are levied against the city. It could also help if the city decides to ask for a higher temporary limit in order to work on the copper problem.

5.2 Effluent Diversion

Another recommendation the group has for the city is to investigate the possibility of diverting plant flow during low flow conditions in the Otter River. A study would have to be performed, as there

are a number of unknown questions about this solution. Such a study would involve finding times in the past that the Gardner WWTF has not met its copper discharge limit and comparing those times to the flow in the Otter River. If such instances occurred during low flow conditions in the Otter River, diversion of the plant effluent may be an option to meet toxicity limits in the river water. The EPA and MassDEP would have to be contacted, as toxicity limits for water bodies are normally specified in units of lb/day, while the NPDES discharge limits are given in ppm or ppb. These agencies would also have to be contacted to see if it would be allowed to use the toxicity limit for the Otter River rather than a plant discharge limit for metals in the river.

Another aspect of the study for effluent diversion would have to include determining the feasibility of either storing the effluent in a holding tank for later release into the Otter River or using it for land application. The study would have to examine regulations and legislation for land use of treated wastewater. Transport of the water, if land application is a recommended use, would also have to be investigated. The other option would include storing the effluent on-site and releasing it slowly into the river when the river flow is higher again. Storage tanks would have to be constructed for this to be a viable option. If the planned addition of equalization tanks to the plant goes through, it may be possible to use such tanks to hold the treated wastewater when they are not in use, which would save the city money. This option is the group's second recommendation, as it would be less costly than building new treatment processes. The drawback to this option however is that much research would need to be done, and it may be possible that the EPA and MassDEP may not allow such diversion and later discharge.

5.3 Chemical Precipitation

The final recommendation for copper removal the group has for the city is to investigate the possibility of adding chemical precipitation to the WWTF. Of the tests conducted in the laboratory by the group, the chemical precipitation worked best to remove both total and dissolved copper. In order for such chemical precipitation to work on such a large scale, new reactors would have to be constructed at the plant, as well as new settling tanks or a filtration unit. This option is the most costly. The sheer magnitude of the capital improvements necessary to successfully remove copper through chemical precipitation may make this option nonviable for the city to consider. This process would also involve one or more long-term pilot studies at the WWTF. These studies would be necessary in order to determine sizes of mixing tanks and filtration units, as well as how much or what chemicals would be used. The effects of adding additional chemicals on other characteristics of the plant water would also have to be investigated. The group recommends that the city look at this option last, as it would be the most costly and would still take some time to implement.

5.4 Operations & Management

As mentioned before, the study that was conducted by the group determined inconclusive methods of treating copper in wastewater at the facility. However, this does not mean that in the future, after other parties perform more research, that the source for high levels of copper in the wastewater will be discovered. Currently, the source is still undetermined but does not have to remain that way for the future. Therefore, recommendations have been made for the WWTF for different

changes and upgrades to the facility that might better identify any future problem and set up and infrastructure at the plant that may be ready for the treatment or side treatment of any influent that cannot be successfully treated at the WWTF. Whether it is implementing a side treatment process for influent that is determined to need additional treatment before flowing to the WWTF, or establishing a state of the art data and tracking system at the WWTF, these recommendations serve as a platform for future problems or instances that may not be relevant and this current point in time.

With upgrades in the near future for the WWTF, there are a few recommendations that can be considered after studying the process and the details involved with influent wastewater, the treatment process, and necessary effluent characteristics. After research was performed by this and previous groups that were studying the copper levels in the wastewater at the WWTF, it was discovered that the most significant levels of copper in the influent to the plant was discharged from Ashburnham. If this trend continues, our group recommends the potential of moving the town of Ashburnham's wastewater discharge into a side stream process. This would entail taking Ashburnham's wastewater discharge and diverting it to its own separate pretreatment process. If Ashburnham's discharge can be treated separately before being included in the WWTF influent it would potentially decrease the high levels of copper, for example, and allow for an easier and much more efficient treatment process. Once a side stream process is established, it would be possible to divert any other wastewater discharges to that side stream process. For example, if it is found that high levels of copper are also involved in the discharge from local industries or the local landfill, those discharges could be treated similarly, bringing the influent to the WWTF to a much more manageable and treatable level.

Although very difficult to implement in a plant that has already been constructed and operating for many years, the implementation of SCADA (Supervisory Control and Data Acquisition) system is also possible. SCADA systems are used to monitor and control a plant. The SCADA system gathers information about the process, for example, if there is a leak occurring, the SCADA system identifies and transfers that information to a central site. A SCADA system would eliminate the need for there to be an operator at the plant at all times and operators could control flow, valves, and treatment equipment remotely from their home or any other location via computer. Not only could an operator control the plant but also supervise and monitor at any point from anywhere via the internet. A SCADA system usually consists of a human-machine interface, a supervisory system, remote terminal units, programmable logic controllers, a communication infrastructure and other process and analytical instrumentation. The implementation of a SCADA system would entail a very large investment, a great amount of time, and the installation of many of the components mentioned previously. However, once the SCADA system was established at the WWTF it would become unnecessary for an operator to be present at the facility at all times. Therefore, electricians and maintenance personnel would be the only absolutely necessary requirement for on-site at the WWTF. If the SCADA system was implemented, it would save time and money in the long-run by permitting an operator to control and supervise the plant from virtually anywhere. Problems with the wastewater treatment system would be known immediately and the operator could then react accordingly whether on site or at a different location.

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Appendix A: Results of Laboratory Experiments

Plant Sampling Routine:

		Influent		Primary Clarifier		Intermediate Clarifier		Final Clarifier		Effluent	
Date	Trial	Total (ppb)	Soluble (ppb)	Total (ppb)	Soluble (ppb)	Total (ppb)	Soluble (ppb)	Total (ppb)	Soluble (ppb)	Total (ppb)	Soluble (ppb)
10/12/11	1	101.00	27.56	33.06	5.67	30.31	3.23	13.38	3.92	13.63	5.77
11/10/11	2	66.78	9.52	34.59	1.91	31.55	2.57	22.69	4.64	17.70	3.40
12/1/11	3	103.80	15.63	55.72	6.96	45.76	11.84	55.71	13.15	27.12	7.28
12/8/11	4	72.20	8.21	43.19	2.77	49.08	3.43	19.12	4.80	11.13	4.33
1/17/12	5	83.81	17.16	61.40	15.72	39.10	7.31	39.22	8.21	31.21	3.00
2/7/12	6	47.64	5.14	31.40	2.49	29.77	3.16	19.56	2.48	38.08	2.82
	Avg.	79.21	13.87	43.23	5.92	37.60	5.26	28.28	6.20	23.15	4.43

Other WWTF Testing:

	Influent		Primary Clarifier		Effluent	
Plant	Total (ppb)	Soluble (ppb)	Total (ppb)	Soluble (ppb)	Total (ppb)	Soluble (ppb)
Marlborough-Westerly	54.96	7.51	46.70	9.35	18.11	1.42
Leominster	24.05	3.01			5.43	1.82
Upper Blackstone	100.20	3.91	31.99	2.35	13.41	1.27
Gardner Average	79.21	13.87	43.23	5.92	23.15	4.43

Filtration Experiment:

Filter Size	Copper (ppb)			
(µm)	Trial 1	Trial 2	Trial 3	Average
0.45	34.68	31.92		33.3
1.2	44.77	40.62	22.59	35.99333333
5	44.67	29.82	16.40	30.29666667
10	57.17	35.69	19.36	37.40666667
Unfiltered	20.85	32.23	19.56	24.21333333
Filter Paper	35.93			35.93

Hardness Testing:

Trial	Effluent Hardness (mg/L as CaCO3)	Upstream Hardness (mg/L as CaCO3)	Downstream Hardness (mg/L as CaCO3)
1	290.7	51.3	68.4
2	239.4	34.2	85.5
3	239.4	34.2	68.4
4	239.4	34.2	51.3
5	222.3	34.2	51.3
6	239.4	34.2	68.4
7	222.3	34.2	51.3
8	239.4	34.2	51.3
9	239.4	34.2	51.3
10	222.3	34.2	51.3
Average	**239.4**	**35.91**	**59.85**

Appendix B: Gardner Business Survey

City of Gardner

Water usage and Wastewater treatment Survey

I. GENERAL INFORMATION

1. Company Name: _____

_____

_____

2. Check one as appropriate:

Proprietorship [ ] Partnership [ ] Corporation [ ]

4. Mailing address: _____

_____

_____

5. Premise address: _____

6. Person to contact concerning information provided in this questionnaire:

Name _____ Title _____

Address _____

_____

Telephone number (_____) _____

II. WATER SOURCE

1. Number and location of private wells, if any, which serve this facility and the approximate total usage of those wells:

_____

2. List all other sources of water that are eventually discharged from your facility: _____

_____

III. PRODUCT OR SERVICE INFORMATION

1. Detailed narrative description of manufacturing or service activity at premise address: (may include additional sheets if necessary): _____

_____

_____

2. Principle raw materials (including chemicals) used: _____

_____

_____

3. Catalysts and/or intermediates used: _____

IV. PLANT OPERATIONAL CHARACTERISTICS

NOTE: "Discharge" in this section refers to process wastes rather than water from fountains, sinks, bathrooms, etc.

1. Approximate number of hours of operation per day: _____

2. Approximate number of employees during peak operation periods:

Full time_____ Part time_____ Other_____

3. Are major products batch, continuous, or both? _____

4. Are your processes subject to seasonal variation? _____

If yes, explain, indicating month(s) of peak operation and products: _____

_____

_____

_____

5. What is your process discharge: _____

6. What is your total facility discharge per day: _____

7. List all holidays that the plant does not have a discharge: _____

_____

_____

8. Circle full months of the year that your plant does not discharge:

J F M A M J J A S O N D

9. Circle full days of the week that your plant does not discharge:

M T W T F S S

10. Check all processes in the Industrial Categories listed below which generate wastewater or waste sludge at this plant's location:

1. [ ] Adhesives	21. [ ] Paint & Ink
2. [ ] Aluminum Forming	22. [ ] Pesticides
3. [ ] Automats & Other Laundries	23. [ ] Petroleum Refining
4. [ ] Battery Manufacturing	24. [ ] Pharmaceuticals
5. [ ] Coal Mining	25. [ ] Photographic Supplies
6. [ ] Coil Coating	26. [ ] Plastic & Synthetic Materials
7. [ ] Copper forming	27. [ ] Plastics Processing
8. [ ] Electric and Electronic Components	28. [ ] Porcelain Enamel
9. [ ] Electroplating	29. [ ] Printing & Publishing
10. [ ] Explosives Manufacturing	30. [ ] Pulp & Paper
11. [ ] Foundries	31. [ ] Rubber
12. [ ] Gum & Wood Chemicals	32. [ ] Soaps & Detergents
13. [ ] Inorganic Chemicals	33. [ ] Steam Electric
14. [ ] Iron & Steel	34. [ ] Textile Mills
15. [ ] Leather Tanning & Finishing	35. [ ] Timber
16. [ ] Mechanical Products	
17. [ ] Metal Finishing	
18. [ ] Nonferrous Metals	
19. [ ] Ore Mining	
20. [ ] Organic Chemicals	

36. Other Processes

[ ] Dairy Products

[ ] Slaughter, Meat Packing, Rendering

[ ] Food or Edible Products Processing

[ ] Beverage Bottling

[ ] Other:_____

[ ] NONE OF THE ABOVE

V. WASTEWATER TREATMENT AND DISCHARGE

1. Check all pretreatment devices or processes used for treating wastewater and/or sludge.

( ) Air flotation
( ) Centrifuge
( ) Chemical precipitation
( ) Chlorination
( ) Cyclone
( ) Filtration
( ) Flow equalization
( ) Grease trap
( ) Grit removal
( ) Ion exchange
( ) Neutralization, pH correctio
( ) Ozonation
( ) Reverse osmosis
( ) Screen
( ) Sedimentation
( ) Septic tank
( ) Solvent separation
( ) Spill protection
( ) Sump

( ) Biological treatment, type:_____

( ) Grease or oil separation type:_____

( ) Rainwater diversion or storage:_____

( ) Other physical treatment:_____

( ) Other chemical treatment:_____

( ) NO PRETREATMENT

2. How often are the above facilities checked for proper operation and/or cleaned?

_____

_____

3. Does the plant discharge water into the City storm sewer or an open drainage way? If not, skip to question 3. If so, give locations and approximate amounts of discharges:

_____

_____

_____

What is the nature of this water (cooling, process, wash, etc…) _____

_____

4. List all other sewage or sludge disposal systems or contract waste haulers, which are utilized:

_____

_____

_____

If waste haulers are utilized, please explain what is hauled, and where it is hauled to:

_____

_____

_____

5. List all environmental control permits now held or issued to this facility: _____

_____

_____

6. If any wastewater analyses have been performed on the process discharge(s) from your facilities, attach a copy of the most recent data to this questionnaire. Be sure to include the date of the analysis, name of laboratory performing the analysis, and location(s) from which the sample(s) were taken (attach sketches, plans, etc., as necessary).

VI. TOXIC POLLUTANTS

1. Pace a check mark next to each toxic pollutant listed below which are being used on the premises or which may result as a by-product and/or eventually enter the public sanitary sewer system, (NRDC Consent decree and referenced in 307a of the Clean Water Act of 1977):

( ) Acenapthene	( ) Dichloropropene
( ) Endrin and metabolites	( ) Toxaphene
( ) Acolein	( ) 2,4-dimethylphenol
( ) Ethylbenzene	( ) Trichloroethylene
( ) Acrylonitrile	( ) Dinitrotoluene
( ) Fluoranthene	( ) Isophorone
( ) Aldrin/Dieldrin	( ) Beryllium and compounds
( ) Haloethers	( ) Lead and compounds
( ) Antimony and compounds	( ) Cadmium and compounds
( ) Halomethanes	( ) Mercury and compounds
( ) Arsenic and compounds	( ) Carbon tetrachloride
( ) Heptachlor & metabolites	( ) Napthalene
( ) Asbestos	( ) Chlordane
( ) Hexachlorobutadiene	( ) Nickel and compounds
( ) Benzene	( ) Chlorinated benzenes
( ) Hexachlorocyclopentadiene	( ) Nitrobenzene
( ) Benzidine	( ) Chlorinated ethanes
( ) Hexachlorocyclohexane	( ) Nitrophenols
( ) Chlorinated phenols	( ) Chlorinated ethers
( ) Pentachlorophenol	( ) Nitrosamines
( ) Chloroform	( ) Chlorinated naphthalene
( ) Phenol	( ) Vinyl chloride
( ) 2-chlorophenol	( ) Diphenylhydrazine
( ) Phthalate esters	( ) Zinc and compounds
( ) Chromium and compounds	( ) Endosulfan & metabolities
( ) Polychlorinated biphenyls (PCBs)	( ) 2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCI
( ) Copper and compounds	( ) Dichlorobenzidine
( ) Polynuclear aromatic hydrocarbons	( ) Tetrachloroethylene
( ) Cyanides	( ) 2,4-dichloroph
( ) Selenium and compounds	( ) Thallium & metabolites
( ) DDT and metabolites	( ) Dichloropropane
( ) Silver and compounds	( ) Toluene
( ) Dichlorobenzenes	

SIGNATURE PAGE

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Signature: _____ Date:_____

Name and title of signing official: _____

Appendix C: Results from AA Testing

Method Name: dpel-Cu Element: Cu Dissolved
Method Description: Copper by Furnace

Date: 10/20/2011
Technique: Furnace
Wavelength: 324.8 nm
Lamp Current: 13
Sample Info File: Untitled

Calibration Equation: Zero Intercept: Linear
Slit Width: 0.70 nm
Energy: 61
Results Data Set:

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 10/20/2011
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.012	0.012	0.011	-0.001	0.002	07:49:56	No
2			0.009	0.009	0.009	-0.002	0.003	07:52:10	No
Mean:			0.011						
SD :			0.002						
%RSD:			19.19						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 10/20/2011
Sample ID: 20ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.232	0.243	0.308	0.001	0.003	07:54:24	No
2			0.244	0.255	0.323	0.001	0.005	07:56:38	No
Mean:			0.238						
SD :			0.008						
%RSD:			3.43						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0119

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 10/20/2011
Sample ID: 30ppb
µL dispensed: 15 from 3

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.385	0.395	0.497	0.001	0.004	07:58:52	No
2			0.394	0.405	0.504	0.002	0.004	08:01:05	No
Mean:			0.389						
SD :			0.007						
%RSD:			1.70						

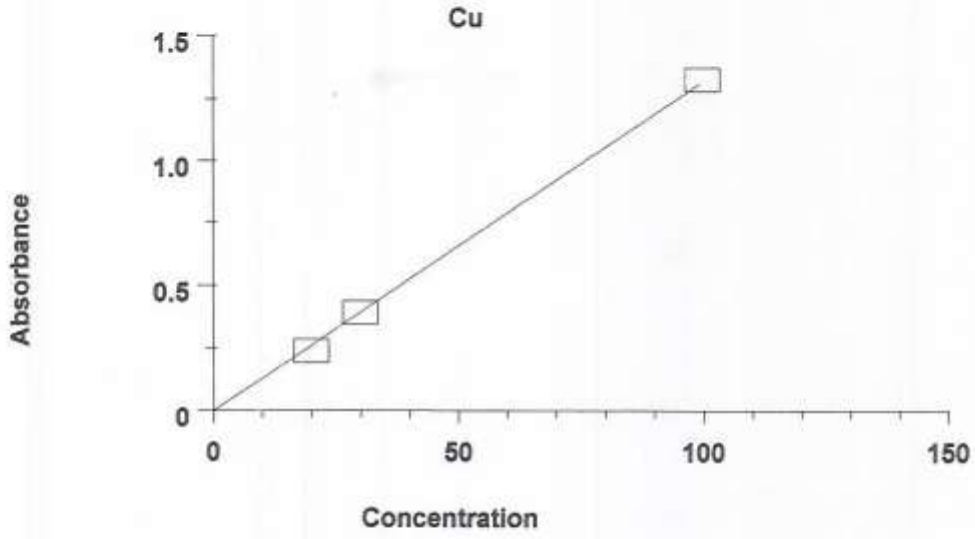
Standard number 2 applied. [30]
Correlation Coefficient: 0.9801 Slope: 0.0127

Page 1

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 10/20/2011
Sample ID: 100ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			1.322	1.333	1.484	0.005	0.006	08:03:19	No
2			1.318	1.329	1.475	0.005	0.006	08:05:33	No
Mean:			1.320						
SD :			0.003						
%RSD:			0.20						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9995 Slope: 0.0131



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.002	19.195
20ppb	0.238	20	18.13	0.008	3.432
30ppb	0.389	30	29.62	0.007	1.698
100ppb	1.320	100	100.4	0.003	0.202

Correlation Coefficient: 0.99949 Slope: 0.01314

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 10/20/2011
Sample ID: NIST 1640
µL dispensed: 15 from 5

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	102.3	102.3	1.344	1.355	1.527	0.005	0.006	08:24:46	No
2	79.16	79.16	1.040	1.051	1.228	0.004	0.006	08:27:00	No
Mean:	90.74	90.74	1.192						
SD :	16.38	16.38	0.215						
%RSD:	18.05	18.05	18.05						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 10/20/2011
Sample ID: 1
µL dispensed: 15 from 6

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	6.167	6.167	0.081	0.092	0.091	-0.001	0.003	08:29:14	No
2	5.298	5.298	0.070	0.081	0.083	-0.001	0.002	08:31:27	No
Mean:	5.733	5.733	0.075						
SD :	0.614	0.614	0.008						
%RSD:	10.71	10.71	10.71						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 10/20/2011
Sample ID: 2
µL dispensed: 15 from 7

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	3.285	3.285	0.043	0.054	0.053	-0.001	0.002	08:33:43	No
2	3.192	3.192	0.042	0.053	0.052	-0.001	0.002	08:35:56	No
Mean:	3.238	3.238	0.043						
SD :	0.066	0.066	0.001						
%RSD:	2.05	2.05	2.05						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 10/20/2011
Sample ID: 3
µL dispensed: 15 from 8

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	29.40	29.40	0.386	0.397	0.505	0.002	0.004	08:38:11	No
2	25.72	25.72	0.338	0.349	0.420	0.001	0.004	08:40:24	No
Mean:	27.56	27.56	0.362						
SD :	2.603	2.603	0.034						
%RSD:	9.44	9.44	9.44						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 10/20/2011
Sample ID: 4
µL dispensed: 15 from 9

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	5.785	5.785	0.076	0.087	0.099	0.000	0.003	08:42:40	No
2	5.555	5.555	0.073	0.084	0.101	0.001	0.002	08:44:54	No
Mean:	5.670	5.670	0.075						
SD :	0.163	0.163	0.002						
%RSD:	2.87	2.87	2.87						

Element: Cu Seq. No.: 10 AS Loc.: 10 Date: 10/20/2011
Sample ID: 5
µL dispensed: 15 from 10

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	4.130	4.130	0.054	0.065	0.079	-0.001	0.003	08:47:08	No
2	3.724	3.724	0.049	0.060	0.075	0.001	0.003	08:49:21	No
Mean:	3.927	3.927	0.052						
SD :	0.287	0.287	0.004						
%RSD:	7.31	7.31	7.31						

Method Name: dpel-Cu Element: Cu
Method Description: Copper by Furnace

Dissolved Cu - Trial

Date: 10/20/2011
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 61
Sample Info File: Untitled Results Data Set:

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 10/20/2011
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.012	0.012	0.011	-0.001	0.002	07:49:56	No
2			0.009	0.009	0.009	-0.002	0.003	07:52:10	No
Mean:			0.011						
SD :			0.002						
%RSD:			19.19						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 10/20/2011
Sample ID: 20ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.232	0.243	0.308	0.001	0.003	07:54:24	No
2			0.244	0.255	0.323	0.001	0.005	07:56:38	No
Mean:			0.238						
SD :			0.008						
%RSD:			3.43						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0119

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 10/20/2011
Sample ID: 30ppb
µL dispensed: 15 from 3

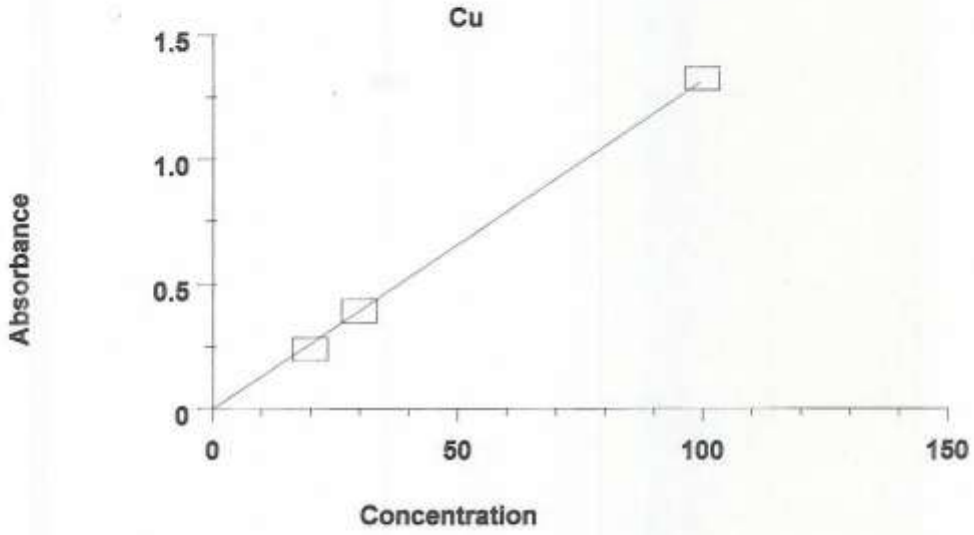
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.385	0.395	0.497	0.001	0.004	07:58:52	No
2			0.394	0.405	0.504	0.002	0.004	08:01:05	No
Mean:			0.389						
SD :			0.007						
%RSD:			1.70						

Standard number 2 applied. [30]
Correlation Coefficient: 0.9801 Slope: 0.0127

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 10/20/2011
Sample ID: 100ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			1.322	1.333	1.484	0.005	0.006	08:03:19	No
2			1.318	1.329	1.475	0.005	0.006	08:05:33	No
Mean:			1.320						
SD :			0.003						
%RSD:			0.20						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9995 Slope: 0.0131



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.002	19.195
20ppb	0.238	20	18.13	0.008	3.432
30ppb	0.389	30	29.62	0.007	1.698
100ppb	1.320	100	100.4	0.003	0.202

Correlation Coefficient: 0.99949 Slope: 0.01314

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 10/20/2011
Sample ID: NIST 1640 Dissolved Copper
µL dispensed: 15 from 5

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	102.3	102.3	1.344	1.355	1.527	0.005	0.006	08:24:46	No
2	79.16	79.16	1.040	1.051	1.228	0.004	0.006	08:27:00	No
Mean:	90.74	90.74	1.192						
SD :	16.38	16.38	0.215						
%RSD:	18.05	18.05	18.05						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 10/20/2011
Sample ID: (1) Effluent
µL dispensed: 15 from 6

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	6.167	6.167	0.081	0.092	0.091	-0.001	0.003	08:29:14	No
2	5.298	5.298	0.070	0.081	0.083	-0.001	0.002	08:31:27	No
Mean:	5.733	5.733	0.075						
SD :	0.614	0.614	0.008						
%RSD:	10.71	10.71	10.71						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 10/20/2011
Sample ID: (2) Intermediate Settling
µL dispensed: 15 from 7

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	3.285	3.285	0.043	0.054	0.053	-0.001	0.002	08:33:43	No
2	3.192	3.192	0.042	0.053	0.052	-0.001	0.002	08:35:56	No
Mean:	3.238	3.238	0.043						
SD :	0.066	0.066	0.001						
%RSD:	2.05	2.05	2.05						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 10/20/2011
Sample ID: (3) Influent
µL dispensed: 15 from 8

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	29.40	29.40	0.386	0.397	0.505	0.002	0.004	08:38:11	No
2	25.72	25.72	0.338	0.349	0.420	0.001	0.004	08:40:24	No
Mean:	27.56	27.56	0.362						
SD :	2.603	2.603	0.034						
%RSD:	9.44	9.44	9.44						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 10/20/2011
Sample ID: (4) Primary Settling
µL dispensed: 15 from 9

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	5.785	5.785	0.076	0.087	0.099	0.000	0.003	08:42:40	No
2	5.555	5.555	0.073	0.084	0.101	0.001	0.002	08:44:54	No
Mean:	5.670	5.670	0.075						
SD :	0.163	0.163	0.002						
%RSD:	2.87	2.87	2.87						

Element: Cu Seq. No.: 10 AS Loc.: 10 Date: 10/20/2011
Sample ID: (5) Secondary Settling
µL dispensed: 15 from 10

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	4.130	4.130	0.054	0.065	0.079	-0.001	0.003	08:47:08	No
2	3.724	3.724	0.049	0.060	0.075	0.001	0.003	08:49:21	No
Mean:	3.927	3.927	0.052						
SD :	0.287	0.287	0.004						
%RSD:	7.31	7.31	7.31						

Digested

Element: Cu Seq. No.: 7 AS Loc.: --- Date: 10/27/2011
Sample ID: Calib Blank

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.000	
2			0.000	07:12:38
Mean:			0.000	07:12:46
SD :			0.000	
%RSD:			52.06	

Auto-zero performed.

Element: Cu Seq. No.: 8 AS Loc.: --- Date: 10/27/2011
Sample ID: .05ppm

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.002	
2			0.002	07:13:14
Mean:			0.002	07:13:23
SD :			0.000	
%RSD:			2.97	

Standard number 1 applied. [0.05]
Correlation Coefficient: 0.9998 Slope: 0.0369

Element: Cu Seq. No.: 9 AS Loc.: --- Date: 10/27/2011
Sample ID: .1ppm

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.004	
2			0.004	07:13:53
Mean:			0.004	07:14:01
SD :			0.000	
%RSD:			1.44	

Standard number 2 applied. [0.1]
Correlation Coefficient: 0.9961 Slope: 0.0376

Element: Cu Seq. No.: 10 AS Loc.: --- Date: 10/27/2011
Sample ID: .2ppm

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.007	
2			0.007	07:14:30
Mean:			0.007	07:14:38
SD :			0.000	
%RSD:			1.29	

Standard number 3 applied. [0.2]
Correlation Coefficient: 0.9969 Slope: 0.0379

Element: Cu Seq. No.: 11 AS Loc.: --- Date: 10/27/2011
Sample ID: NIST1640

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1	0.087	0.087	0.003	07:15:24
2	0.081	0.081	0.003	07:15:33
Mean:	0.084	0.084	0.003	
SD :	0.004	0.004	0.000	
%RSD:	4.92	4.92	4.92	

Element: Cu Seq. No.: 12 AS Loc.: --- Date: 10/27/2011
Sample ID: 3 influent

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1	0.101	0.101	0.004	07:15:59
2	0.101	0.101	0.004	07:16:08
Mean:	0.101	0.101	0.004	
SD :	0.000	0.000	0.000	
%RSD:	0.10	0.10	0.10	

Method Name: dpel-Cu Element: Cu Digested
Method Description: Copper by Furnace

Date: 10/27/2011
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 59
Sample Info File: MQP-CU.SIF Results Data Set:

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 10/27/2011
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.040	0.040	0.063	-0.002	0.002	11:43:27	No

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 10/27/2011
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.023	0.023	0.026	-0.003	0.003	11:46:03	No
2			0.013	0.013	0.013	-0.002	0.002	11:48:17	No
Mean:			0.018						
SD :			0.007						
%RSD:			36.54						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 10/27/2011
Sample ID: 20ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.190	0.208	0.266	-0.001	0.003	11:50:31	No
2			0.213	0.231	0.298	-0.001	0.002	11:52:44	No
Mean:			0.201						
SD :			0.016						
%RSD:			8.12						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0101

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 10/27/2011
Sample ID: 30ppb
µL dispensed: 15 from 3

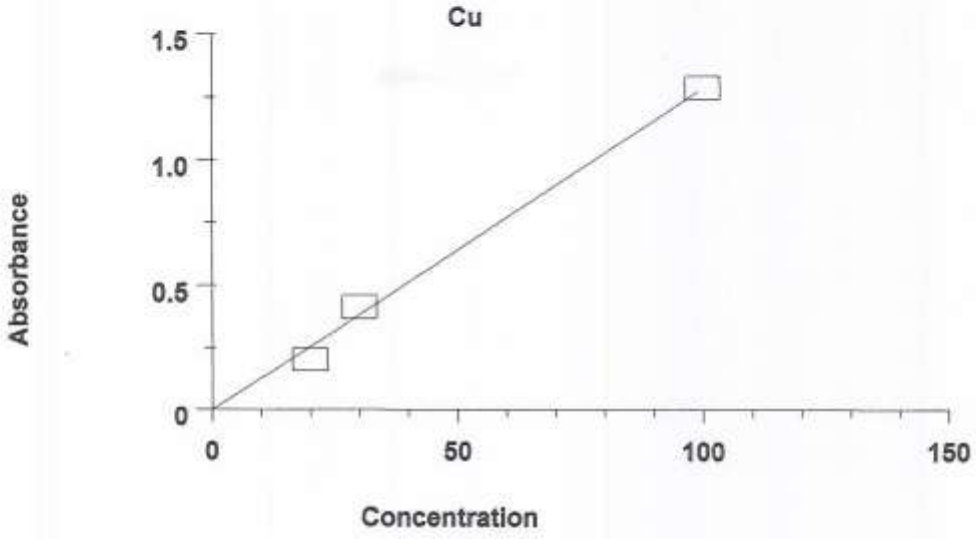
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.407	0.425	0.534	0.000	0.004	11:54:58	No
2			0.421	0.439	0.550	0.000	0.003	11:57:13	No
Mean:			0.414						
SD :			0.010						
%RSD:			2.48						

Standard number 2 applied. [30]
Correlation Coefficient: 0.7281 Slope: 0.0129

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 10/27/2011
Sample ID: 100ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			1.271	1.289	1.456	0.002	0.005	11:59:27	No
2			1.298	1.316	1.480	0.003	0.006	12:01:41	No
Mean:			1.284						
SD :			0.019						
%RSD:			1.49						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9969 Slope: 0.0128



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.007	36.545
20ppb	0.201	20	15.68	0.016	8.124
30ppb	0.414	30	32.20	0.010	2.480
100ppb	1.284	100	99.97	0.019	1.494

Correlation Coefficient: 0.99690 Slope: 0.01285

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 10/27/2011
Sample ID: (1)
µL dispensed: 15 from 5 effluent

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	33.74	33.74	0.433	0.451	0.539	0.000	0.004	12:15:42	No
2	14.92	14.92	0.192	0.210	0.243	0.000	0.003	12:17:57	No
Mean:	24.33	24.33	0.313						
SD :	13.30	13.30	0.171						
%RSD:	54.67	54.67	54.67						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 10/27/2011
Sample ID: (2)
µL dispensed: 15 from 6 intermediate clarifier

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	30.05	30.05	0.386	0.404	0.486	0.000	0.004	12:20:11	No
2	30.57	30.57	0.393	0.411	0.490	0.000	0.004	12:22:25	No
Mean:	30.31	30.31	0.389						
SD :	0.370	0.370	0.005						
%RSD:	1.22	1.22	1.22						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 10/27/2011
Sample ID: (4)
µL dispensed: 15 from 7 primary clarifier

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	33.20	33.20	0.427	0.445	0.531	-0.001	0.004	12:24:39	No
2	32.91	32.91	0.423	0.441	0.526	0.000	0.003	12:26:53	No
Mean:	33.06	33.06	0.425						
SD :	0.204	0.204	0.003						
%RSD:	0.62	0.62	0.62						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 10/27/2011
Sample ID: (5)
µL dispensed: 15 from 8 final clarifier

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	13.52	13.52	0.174	0.192	0.226	-0.001	0.002	12:29:07	No
2	13.25	13.25	0.170	0.188	0.224	-0.001	0.003	12:31:22	No
Mean:	13.38	13.38	0.172						
SD :	0.191	0.191	0.002						
%RSD:	1.43	1.43	1.43						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 10/27/2011
Sample ID: NIST 1640
µL dispensed: 15 from 9

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	75.37	75.37	0.968	0.986	1.142	0.002	0.005	12:33:36	No
2	74.03	74.03	0.951	0.969	1.125	0.001	0.005	12:35:49	No
Mean:	74.70	74.70	0.960						
SD :	0.948	0.948	0.012						
%RSD:	1.27	1.27	1.27						

Element: Cu Seq. No.: 10 AS Loc.: 5 Date: 10/27/2011
Sample ID: 1
µL dispensed: 15 from 5 effluent

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	13.68	13.68	0.176	0.194	0.237	-0.002	0.003	12:45:47	No
2	13.58	13.58	0.175	0.193	0.234	-0.002	0.003	12:48:01	No
Mean:	13.63	13.63	0.175						
SD :	0.069	0.069	0.001						
%RSD:	0.51	0.51	0.51						

Method Name: dpel-Cu Element: Cu Total Cu - Trial 1
Method Description: Copper by Furnace

Date: 10/27/2011
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 59
Sample Info File: MQP-CU.SIF Results Data Set:

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 10/27/2011
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.040	0.040	0.063	-0.002	0.002	11:43:27	No

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 10/27/2011
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.023	0.023	0.026	-0.003	0.003	11:46:03	No
2			0.013	0.013	0.013	-0.002	0.002	11:48:17	No
Mean:			0.018						
SD :			0.007						
%RSD:			36.54						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 10/27/2011
Sample ID: 20ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.190	0.208	0.266	-0.001	0.003	11:50:31	No
2			0.213	0.231	0.298	-0.001	0.002	11:52:44	No
Mean:			0.201						
SD :			0.016						
%RSD:			8.12						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0101

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 10/27/2011
Sample ID: 30ppb
µL dispensed: 15 from 3

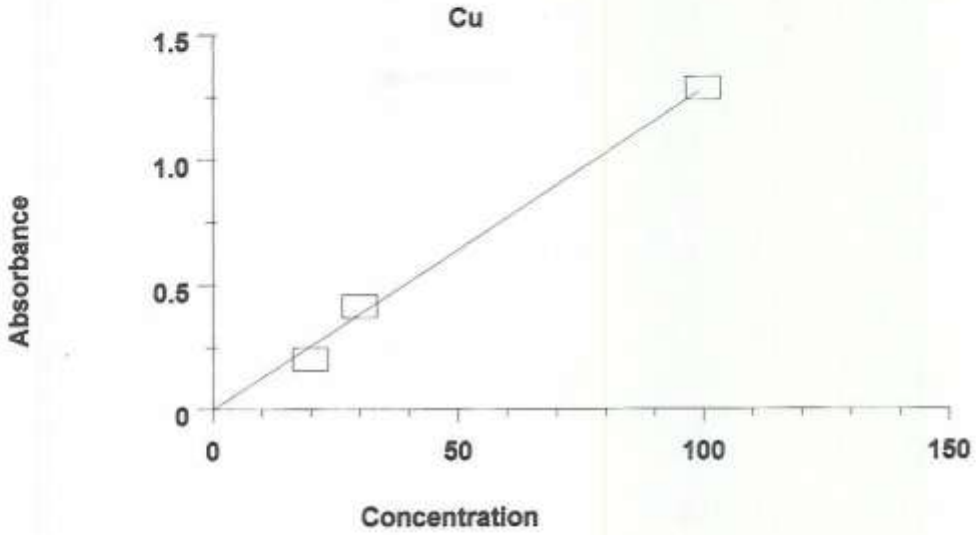
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.407	0.425	0.534	0.000	0.004	11:54:58	No
2			0.421	0.439	0.550	0.000	0.003	11:57:13	No
Mean:			0.414						
SD :			0.010						
%RSD:			2.48						

Standard number 2 applied. [30]
Correlation Coefficient: 0.7281 Slope: 0.0129

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 10/27/2011
Sample ID: 100ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			1.271	1.289	1.456	0.002	0.005	11:59:27	No
2			1.298	1.316	1.480	0.003	0.006	12:01:41	No
Mean:			1.284						
SD :			0.019						
%RSD:			1.49						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9969 Slope: 0.0128



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.007	36.545
20ppb	0.201	20	15.68	0.016	8.124
30ppb	0.414	30	32.20	0.010	2.480
100ppb	1.284	100	99.97	0.019	1.494

Correlation Coefficient: 0.99690 Slope: 0.01285

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 10/27/2011
Sample ID: ④ ~~Effluent~~
µL dispensed: 15 from 5

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	33.74	33.74	0.433	0.451	0.539	0.000	0.004	12:15:42	No
2	14.92	14.92	0.192	0.210	0.243	0.000	0.003	12:17:57	No
Mean:	24.33	24.33	0.313						
SD :	13.30	13.30	0.171						
%RSD:	54.67	54.67	54.67						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 10/27/2011
Sample ID: ② Intermediate Settling
µL dispensed: 15 from 6

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	30.05	30.05	0.386	0.404	0.486	0.000	0.004	12:20:11	No
2	30.57	30.57	0.393	0.411	0.490	0.000	0.004	12:22:25	No
Mean:	30.31	30.31	0.389						
SD :	0.370	0.370	0.005						
%RSD:	1.22	1.22	1.22						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 10/27/2011
Sample ID: ④ Primary Settling
µL dispensed: 15 from 7

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	33.20	33.20	0.427	0.445	0.531	-0.001	0.004	12:24:39	No
2	32.91	32.91	0.423	0.441	0.526	0.000	0.003	12:26:53	No
Mean:	33.06	33.06	0.425						
SD :	0.204	0.204	0.003						
%RSD:	0.62	0.62	0.62						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 10/27/2011
Sample ID: ⑤ Secondary Settling
µL dispensed: 15 from 8

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	13.52	13.52	0.174	0.192	0.226	-0.001	0.002	12:29:07	No
2	13.25	13.25	0.170	0.188	0.224	-0.001	0.003	12:31:22	No
Mean:	13.38	13.38	0.172						
SD :	0.191	0.191	0.002						
%RSD:	1.43	1.43	1.43						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 10/27/2011
Sample ID: NIST 1640
µL dispensed: 15 from 9

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	75.37	75.37	0.968	0.986	1.142	0.002	0.005	12:33:36	No
2	74.03	74.03	0.951	0.969	1.125	0.001	0.005	12:35:49	No
Mean:	74.70	74.70	0.960						
SD :	0.948	0.948	0.012						
%RSD:	1.27	1.27	1.27						

Element: Cu Seq. No.: 10 AS Loc.: 5 Date: 10/27/2011
Sample ID: (1) Effluent
µL dispensed: 15 from 5

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	13.68	13.68	0.176	0.194	0.237	-0.002	0.003	12:45:47	No
2	13.58	13.58	0.175	0.193	0.234	-0.002	0.003	12:48:01	No
Mean:	13.63	13.63	0.175						
SD :	0.069	0.069	0.001						
%RSD:	0.51	0.51	0.51						

Total Cu

Element: Cu Seq. No.: 7 AS Loc.: --- Date: 10/27/2011
Sample ID: Calib Blank

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.000	07:12:38
2			0.000	07:12:46
Mean:			0.000	
SD :			0.000	
%RSD:			52.06	

Auto-zero performed.

Element: Cu Seq. No.: 8 AS Loc.: --- Date: 10/27/2011
Sample ID: .05ppm

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.002	07:13:14
2			0.002	07:13:23
Mean:			0.002	
SD :			0.000	
%RSD:			2.97	

Standard number 1 applied. [0.05]
Correlation Coefficient: 0.9998 Slope: 0.0369

Element: Cu Seq. No.: 9 AS Loc.: --- Date: 10/27/2011
Sample ID: .1ppm

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.004	07:13:53
2			0.004	07:14:01
Mean:			0.004	
SD :			0.000	
%RSD:			1.44	

Standard number 2 applied. [0.1]
Correlation Coefficient: 0.9961 Slope: 0.0376

Element: Cu Seq. No.: 10 AS Loc.: --- Date: 10/27/2011
Sample ID: .2ppm

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.007	07:14:30
2			0.007	07:14:38
Mean:			0.007	
SD :			0.000	
%RSD:			1.29	

Standard number 3 applied. [0.2]
Correlation Coefficient: 0.9969 Slope: 0.0379

Element: Cu Seq. No.: 11 AS Loc.: --- Date: 10/27/2011
Sample ID: NIST1640

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1	0.087	0.087	0.003	07:15:24
2	0.081	0.081	0.003	07:15:33
Mean:	0.084	0.084	0.003	
SD :	0.004	0.004	0.000	
%RSD:	4.92	4.92	4.92	

Element: Cu Seq. No.: 12 AS Loc.: --- Date: 10/27/2011
Sample ID: (3) Influent

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1	0.101	0.101	0.004	07:15:59
2	0.101	0.101	0.004	07:16:08
Mean:	0.101	0.101	0.004	
SD :	0.000	0.000	0.000	
%RSD:	0.10	0.10	0.10	

Trial 2 - Total Cu

DIGESTED FURNACE

Method Name: dpel-Cu Element: Cu
Method Description: Copper by Furnace

Date: 11/21/2011
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 61
Sample Info File: Untitled Results Data Set:

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 11/21/2011
Sample ID: Calib Blank
µL dispensed: 10 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.031	0.031	0.036	-0.001	0.002	09:15:55	No

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 11/21/2011
Sample ID: Calib Blank
µL dispensed: 10 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.003	0.003	0.005	-0.001	0.003	09:18:32	No
2			0.010	0.010	0.014	-0.002	0.002	09:20:46	No
Mean:			0.006						
SD :			0.005						
%RSD:			84.93						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 11/21/2011
Sample ID: 20ppb
µL dispensed: 10 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.117	0.123	0.159	0.000	0.003	09:23:01	No
2			0.131	0.138	0.179	0.000	0.003	09:25:14	No
Mean:			0.124						
SD :			0.010						
%RSD:			8.22						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0062

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 11/21/2011
Sample ID: 50ppb
µL dispensed: 10 from 3

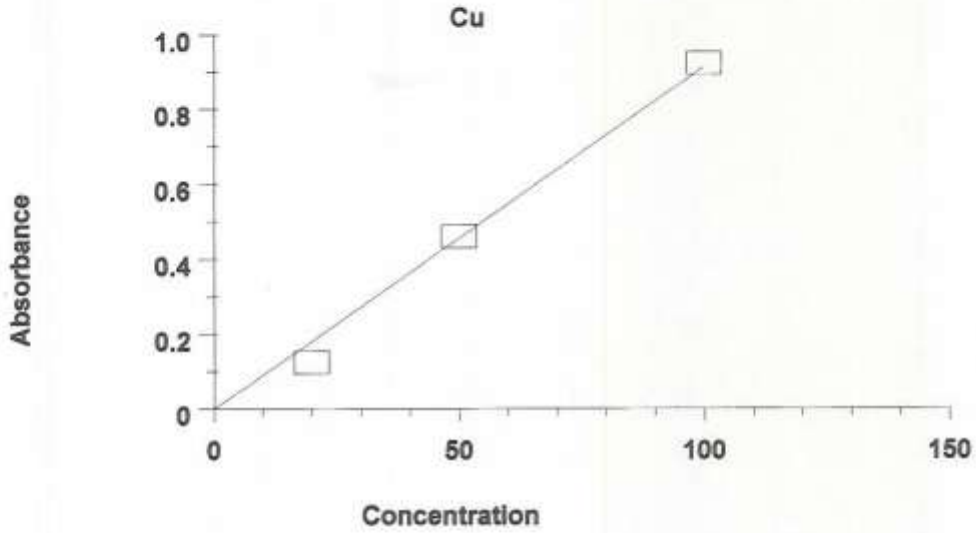
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.443	0.450	0.561	0.001	0.005	09:27:29	No
2			0.474	0.480	0.593	0.002	0.004	09:29:42	No
Mean:			0.459						
SD :			0.021						
%RSD:			4.64						

Standard number 2 applied. [50]
Correlation Coefficient: 0.9554 Slope: 0.0089

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 11/21/2011
Sample ID: 100ppb
µL dispensed: 10 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.914	0.921	1.081	0.004	0.006	09:31:57	No
2			0.927	0.933	1.093	0.004	0.005	09:34:11	No
Mean:			0.921						
SD :			0.009						
%RSD:			0.96						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9935 Slope: 0.0091



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.005	84.933
20ppb	0.124	20	13.56	0.010	8.222
50ppb	0.459	50	50.19	0.021	4.639
100ppb	0.921	100	100.8	0.009	0.960

Correlation Coefficient: 0.99354 Slope: 0.00914

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 11/21/2011
Sample ID: (1)
µL dispensed: 10 from 5 influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	78.75	78.75	0.719	0.726	0.859	0.003	0.005	09:37:05	No
2	54.81	54.81	0.501	0.507	0.560	0.003	0.005	09:39:19	No
Mean:	66.78	66.78	0.610						
SD :	16.93	16.93	0.155						
%RSD:	25.35	25.35	25.35						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 11/21/2011
Sample ID: (2)
µL dispensed: 10 from 6 primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	35.30	35.30	0.322	0.329	0.393	0.002	0.004	09:41:34	No
2	33.89	33.89	0.310	0.316	0.377	0.001	0.003	09:43:47	No
Mean:	34.59	34.59	0.316						
SD :	0.999	0.999	0.009						
%RSD:	2.89	2.89	2.89						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 11/21/2011
Sample ID: (3)
µL dispensed: 10 from 7 intermediate

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	32.35	32.35	0.296	0.302	0.368	0.002	0.003	09:46:03	No
2	30.75	30.75	0.281	0.287	0.343	0.001	0.004	09:48:17	No
Mean:	31.55	31.55	0.288						
SD :	1.135	1.135	0.010						
%RSD:	3.60	3.60	3.60						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 11/21/2011
Sample ID: (4)
µL dispensed: 10 from 8 final

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	22.88	22.88	0.209	0.215	0.271	0.001	0.004	09:50:33	No
2	22.49	22.49	0.206	0.212	0.267	0.001	0.003	09:52:46	No
Mean:	22.69	22.69	0.207						
SD :	0.274	0.274	0.003						
%RSD:	1.21	1.21	1.21						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 11/21/2011
Sample ID: (5) effluent
µL dispensed: 10 from 9

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	17.55	17.55	0.160	0.167	0.207	0.000	0.003	09:55:01	No
2	17.86	17.86	0.163	0.170	0.210	-0.001	0.003	09:57:14	No
Mean:	17.70	17.70	0.162						
SD :	0.224	0.224	0.002						
%RSD:	1.27	1.27	1.27						

Element: Cu Seq. No.: 10 AS Loc.: 10 Date: 11/21/2011
Sample ID: (6) Ashburnham
µL dispensed: 10 from 10

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	74.67	74.67	0.682	0.689	0.753	0.004	0.005	09:59:31	No
2	75.31	75.31	0.688	0.694	0.749	0.004	0.005	10:01:44	No
Mean:	74.99	74.99	0.685						
SD :	0.450	0.450	0.004						
%RSD:	0.60	0.60	0.60						

Element: Cu Seq. No.: 11 AS Loc.: 11 Date: 11/21/2011
Sample ID: (7) Belt Press
µL dispensed: 10 from 11

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	35.50	35.50	0.324	0.331	0.443	0.004	0.006	10:03:59	No
2	32.41	32.41	0.296	0.303	0.403	0.004	0.005	10:06:13	No
Mean:	33.95	33.95	0.310						
SD :	2.182	2.182	0.020						
%RSD:	6.43	6.43	6.43						

Trial 2 – Dissolved Cu

Element: Cu Seq. No.: 7 AS Loc.: 5 Date: 11/17/2011
Sample ID: 1
µL dispensed: 15 from 5 influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	9.433	9.433	0.159	0.166	0.224	0.001	0.004	12:35:36	No
2	9.622	9.622	0.162	0.169	0.224	0.000	0.004	12:37:50	No
Mean:	9.528	9.528	0.160						
SD :	0.134	0.134	0.002						
%RSD:	1.40	1.40	1.40						

Element: Cu Seq. No.: 8 AS Loc.: 6 Date: 11/17/2011
Sample ID: 2
µL dispensed: 15 from 6 primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	1.914	1.914	0.032	0.039	0.044	-0.001	0.002	12:40:05	No
2	1.903	1.903	0.032	0.039	0.046	-0.001	0.002	12:42:19	No
Mean:	1.909	1.909	0.032						
SD :	0.008	0.008	0.000						
%RSD:	0.40	0.40	0.40						

Element: Cu Seq. No.: 9 AS Loc.: 7 Date: 11/17/2011
Sample ID: 3
µL dispensed: 15 from 7 intermediate

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	2.597	2.597	0.044	0.051	0.063	0.000	0.003	12:44:34	No
2	2.532	2.532	0.043	0.050	0.060	0.000	0.003	12:46:49	No
Mean:	2.565	2.565	0.043						
SD :	0.047	0.047	0.001						
%RSD:	1.81	1.81	1.81						

Element: Cu Seq. No.: 10 AS Loc.: 8 Date: 11/17/2011
Sample ID: 4
µL dispensed: 15 from 8 final

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	4.734	4.734	0.080	0.087	0.113	0.000	0.002	12:49:03	No
2	4.535	4.535	0.076	0.084	0.109	0.000	0.003	12:51:18	No
Mean:	4.635	4.635	0.078						
SD :	0.141	0.141	0.002						
%RSD:	3.04	3.04	3.04						

Element: Cu Seq. No.: 11 AS Loc.: 9 Date: 11/17/2011
Sample ID: (5)
µL dispensed: 15 from 9 Effluent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	3.369	3.369	0.057	0.064	0.085	0.001	0.004	12:53:33	No
2	3.428	3.428	0.058	0.065	0.083	-0.001	0.002	12:55:47	No
Mean:	3.399	3.399	0.057						
SD :	0.041	0.041	0.001						
%RSD:	1.21	1.21	1.21						

Element: Cu Seq. No.: 12 AS Loc.: 10 Date: 11/17/2011
Sample ID: (6)
µL dispensed: 15 from 10 Ashburnham

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	16.93	16.93	0.285	0.292	0.364	0.002	0.004	12:58:02	No
2	16.34	16.34	0.275	0.282	0.349	0.002	0.004	13:01:01	No
Mean:	16.64	16.64	0.280						
SD :	0.417	0.417	0.007						
%RSD:	2.51	2.51	2.51						

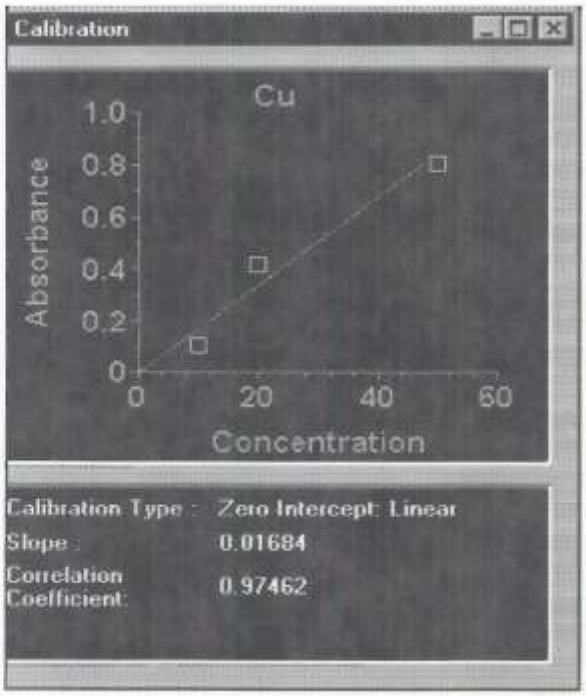
Element: Cu Seq. No.: 13 AS Loc.: 11 Date: 11/17/2011
Sample ID: (7)
µL dispensed: 15 from 11 Belt Press

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	0.661	0.661	0.011	0.018	0.024	0.001	0.004	13:03:03	No
2	0.560	0.560	0.009	0.017	0.021	0.001	0.004	13:05:17	No
Mean:	0.611	0.611	0.010						
SD :	0.072	0.072	0.001						
%RSD:	11.72	11.72	11.72						

Sample Information File Untitled

Description :
Batch ID :
Volume Units : mL
Weight Units :
Analyst :
Sample Volume : 50.000
Nominal Weight : 1.000000

AS Loc	Sample ID	Sample Weight	Sample Units	User Dilution	Remarks
5	1		ppb (Wt/Vol		
6	2		ppb (Wt/Vol		
7	3		ppb (Wt/Vol		
8	4		ppb (Wt/Vol		
9	5		ppb (Wt/Vol		
10	6		ppb (Wt/Vol		
11	7		ppb (Wt/Vol		


Calibration
Cu
1.0
0.8
0.6
0.4
0.2
0
Absorbance
0
20
40
60
Concentration
Calibration Type : Zero Intercept Linear
Slope : 0.01684
Correlation Coefficient: 0.97462

Method Name: dpel-Cu Element: Cu DISSOLVED
Method Description: Copper by Furnace

Date: 12/06/2011
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 60
Sample Info File: Untitled Results Data Set:

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 12/06/2011
Sample ID: Calib Blank
µL dispensed: 10 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.030	0.030	0.026	0.000	0.003	10:05:14	No

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 12/06/2011
Sample ID: Calib Blank
µL dispensed: 10 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.016	0.016	0.016	0.000	0.003	10:07:47	No

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 12/06/2011
Sample ID: Calib Blank
µL dispensed: 10 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.013	0.013	0.013	0.000	0.003	10:10:26	No
2			0.010	0.010	0.011	-0.001	0.002	10:12:40	No
Mean:			0.012						
SD :			0.002						
%RSD:			16.49						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 12/06/2011
Sample ID: 10ppb
µL dispensed: 10 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.047	0.059	0.075	-0.001	0.002	10:14:55	No
2			0.046	0.057	0.074	0.001	0.003	10:17:09	No
Mean:			0.046						
SD :			0.001						
%RSD:			1.78						

Standard number 1 applied. [10]
Correlation Coefficient: 1.0000 Slope: 0.0046

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 12/06/2011
Sample ID: 30ppb
µL dispensed: 10 from 3

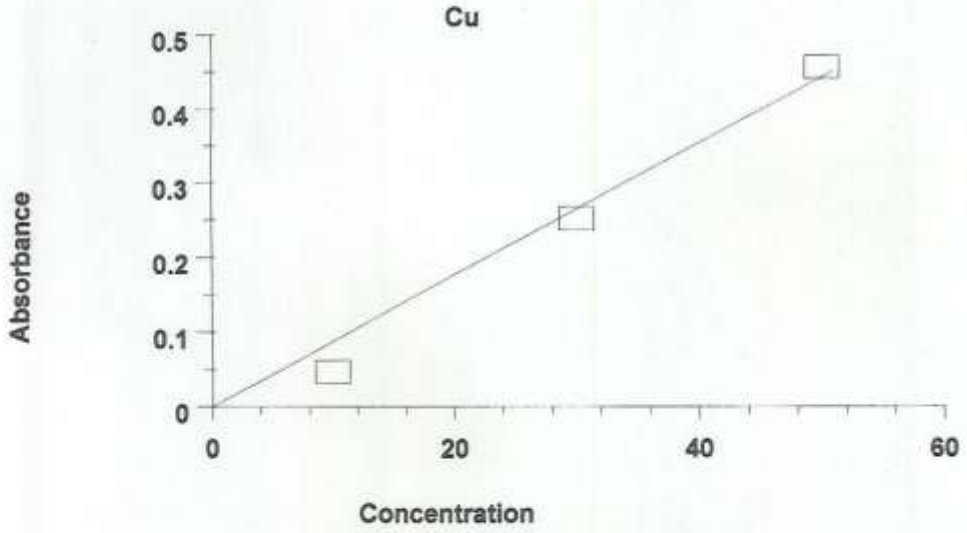
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.241	0.252	0.328	0.001	0.004	10:19:26	No
2			0.260	0.271	0.352	0.001	0.003	10:21:40	No
Mean:			0.250						
SD :			0.014						
%RSD:			5.41						

Standard number 2 applied. [30]
Correlation Coefficient: 0.9505 Slope: 0.0081

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 12/06/2011
Sample ID: 50ppb
µL dispensed: 10 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.448	0.460	0.582	0.002	0.004	10:23:54	No
2			0.457	0.469	0.592	0.002	0.005	10:26:08	No
Mean:			0.453						
SD :			0.006						
%RSD:			1.42						

The calibration curve may not be linear.
Standard number 3 applied. [50]
Correlation Coefficient: 0.9828 Slope: 0.0088



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.002	16.486
10ppb	0.046	10	5.232	0.001	1.777
30ppb	0.250	30	28.38	0.014	5.412
50ppb	0.453	50	51.38	0.006	1.418

Correlation Coefficient: 0.98281 Slope: 0.00881

Method Name: dpel-Cu Element: Cu
Method Description: Copper by Furnace

Date: 12/06/2011
Technique: Furnace
Wavelength: 324.8 nm
Lamp Current: 13
Sample Info File: Untitled

Calibration Equation: Zero Intercept: Linear
Slit Width: 0.70 nm
Energy: 60
Results Data Set: Cu-MQP-12-6-11

Element: Cu Seq. No.: 1 AS Loc.: 5 Date: 12/06/2011
Sample ID: 1
µL dispensed: 10 from 5 influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	16.02	16.02	0.141	0.153	0.201	0.001	0.003	10:30:31	No
2	15.23	15.23	0.134	0.146	0.195	0.002	0.003	10:32:47	No
Mean:	15.63	15.63	0.138						
SD :	0.555	0.555	0.005						
%RSD:	3.55	3.55	3.55						

Element: Cu Seq. No.: 2 AS Loc.: 6 Date: 12/06/2011
Sample ID: 2
µL dispensed: 10 from 6 primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	6.898	6.898	0.061	0.073	0.089	0.000	0.002	10:35:01	No
2	7.017	7.017	0.062	0.074	0.092	0.000	0.002	10:37:15	No
Mean:	6.957	6.957	0.061						
SD :	0.084	0.084	0.001						
%RSD:	1.20	1.20	1.20						

Element: Cu Seq. No.: 3 AS Loc.: 7 Date: 12/06/2011
Sample ID: 3
µL dispensed: 10 from 7 intermediate

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	11.77	11.77	0.104	0.116	0.149	0.002	0.003	10:39:30	No
2	11.91	11.91	0.105	0.117	0.147	0.001	0.004	10:41:43	No
Mean:	11.84	11.84	0.104						
SD :	0.100	0.100	0.001						
%RSD:	0.84	0.84	0.84						

Element: Cu Seq. No.: 4 AS Loc.: 8 Date: 12/06/2011
Sample ID: 4
µL dispensed: 10 from 8 final

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	13.17	13.17	0.116	0.128	0.169	0.000	0.004	10:43:59	No
2	13.13	13.13	0.116	0.128	0.167	0.000	0.003	10:46:13	No
Mean:	13.15	13.15	0.116						
SD :	0.024	0.024	0.000						
%RSD:	0.18	0.18	0.18						

Element: Cu Seq. No.: 5 AS Loc.: 9 Date: 12/06/2011
Sample ID: 5
µL dispensed: 10 from 9 effluent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	7.552	7.552	0.067	0.078	0.101	0.000	0.002	10:48:28	No
2	7.011	7.011	0.062	0.074	0.093	-0.001	0.003	10:50:42	No
Mean:	7.282	7.282	0.064						
SD :	0.383	0.383	0.003						
%RSD:	5.26	5.26	5.26						

Element: Cu Seq. No.: 6 AS Loc.: 10 Date: 12/06/2011
Sample ID: 6
µL dispensed: 10 from 10 MW influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	7.605	7.605	0.067	0.079	0.099	0.000	0.004	10:52:56	No
2	7.420	7.420	0.065	0.077	0.099	0.001	0.003	10:55:11	No
Mean:	7.512	7.512	0.066						
SD :	0.130	0.130	0.001						
%RSD:	1.74	1.74	1.74						

Element: Cu Seq. No.: 7 AS Loc.: 11 Date: 12/06/2011
Sample ID: 7
µL dispensed: 10 from 11 MW primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	9.379	9.379	0.083	0.094	0.121	-0.002	0.002	10:57:25	No
2	9.321	9.321	0.082	0.094	0.123	-0.001	0.002	10:59:39	No
Mean:	9.350	9.350	0.082						
SD :	0.041	0.041	0.000						
%RSD:	0.44	0.44	0.44						

Element: Cu Seq. No.: 8 AS Loc.: 12 Date: 12/06/2011
Sample ID: 8
µL dispensed: 10 from 12 MW effluent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	1.494	1.494	0.013	0.025	0.032	0.000	0.004	11:01:54	No
2	1.336	1.336	0.012	0.024	0.032	0.000	0.003	11:04:08	No
Mean:	1.415	1.415	0.012						
SD :	0.112	0.112	0.001						
%RSD:	7.90	7.90	7.90						

Element: Cu Seq. No.: 9 AS Loc.: 13 Date: 12/06/2011
Sample ID: NIST 1640
µL dispensed: 10 from 13

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	99.54	49.77	0.439	0.450	0.591	0.001	0.003	11:06:23	No
2	88.91	44.46	0.392	0.404	0.536	0.002	0.004	11:08:37	No
Mean:	94.23	47.11	0.415						
SD :	7.516	3.758	0.033						
%RSD:	7.98	7.98	7.98						

Method Name: dpel-Cu Element: Cu
Method Description: Copper by Furnace

Date: 12/06/2011
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 60
Sample Info File: Untitled Results Data Set: Cu MQP 12-6 Dig DIGESTED

Element: Cu Seq. No.: 4 AS Loc.: 1 Date: 12/06/2011
Sample ID: Calib Blank
µL dispensed: 7 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.006	0.006	0.006	0.000	0.003	13:25:49	No
2			0.005	0.005	0.005	-0.001	0.002	13:28:02	No
Mean:			0.005						
SD :			0.001						
%RSD:			10.32						

Auto-zero performed.

Element: Cu Seq. No.: 5 AS Loc.: 2 Date: 12/06/2011
Sample ID: 20ppb
µL dispensed: 7 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.071	0.076	0.102	0.000	0.003	13:30:17	No
2			0.075	0.080	0.109	0.000	0.003	13:32:31	No
Mean:			0.073						
SD :			0.002						
%RSD:			3.42						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0036

Element: Cu Seq. No.: 6 AS Loc.: 3 Date: 12/06/2011
Sample ID: 50ppb
µL dispensed: 7 from 3

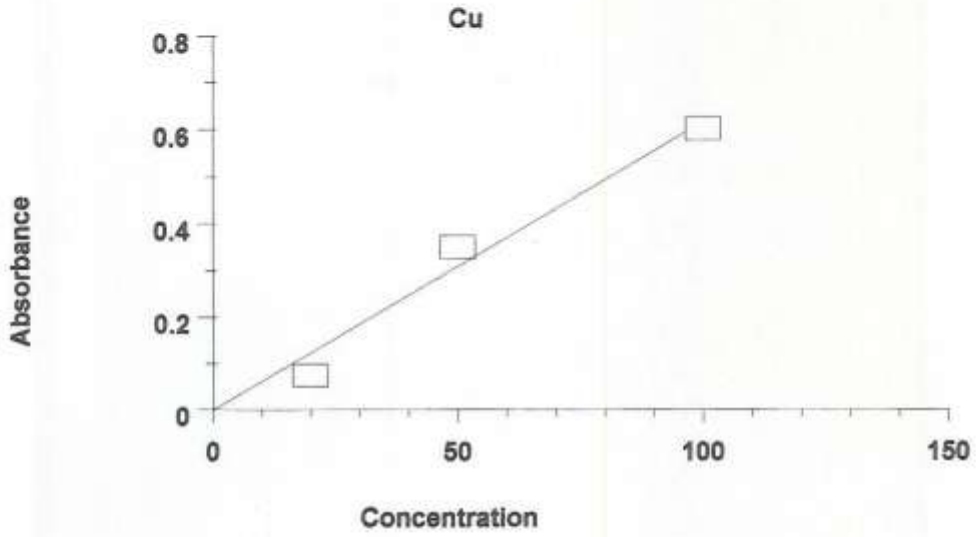
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.358	0.364	0.472	0.001	0.004	13:34:45	No
2			0.339	0.344	0.447	0.002	0.004	13:36:58	No
Mean:			0.349						
SD :			0.014						
%RSD:			3.90						

Standard number 2 applied. [50]
Correlation Coefficient: 0.8975 Slope: 0.0067

Element: Cu Seq. No.: 7 AS Loc.: 4 Date: 12/06/2011
Sample ID: 100ppb
µL dispensed: 7 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.599	0.604	0.761	0.003	0.005	13:39:13	No
2			0.602	0.607	0.760	0.003	0.005	13:41:26	No
Mean:			0.600						
SD :			0.002						
%RSD:			0.36						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9819 Slope: 0.0062



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.001	10.318
20ppb	0.073	20	11.80	0.002	3.420
50ppb	0.349	50	56.48	0.014	3.899
100ppb	0.600	100	97.23	0.002	0.362

Correlation Coefficient: 0.98193 Slope: 0.00618

Element: Cu Seq. No.: 8 AS Loc.: 5 Date: 12/06/2011
Sample ID: 1
µL dispensed: 7 from 5 influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	112.4	112.4	0.694	0.699	0.788	0.004	0.005	13:44:41	No
Sample absorbance is greater than that of the highest standard.									
2	95.23	95.23	0.588	0.593	0.744	0.003	0.005	13:46:54	No
Mean:	103.8	103.8	0.641						
SD :	12.13	12.13	0.075						
%RSD:	11.68	11.68	11.68						

Element: Cu Seq. No.: 9 AS Loc.: 6 Date: 12/06/2011
Sample ID: 2
µL dispensed: 7 from 6 primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	60.09	60.09	0.371	0.376	0.462	0.002	0.004	13:49:09	No
2	51.35	51.35	0.317	0.322	0.361	0.002	0.003	13:51:23	No
Mean:	55.72	55.72	0.344						
SD :	6.180	6.180	0.038						
%RSD:	11.09	11.09	11.09						

Element: Cu Seq. No.: 10 AS Loc.: 7 Date: 12/06/2011
Sample ID: 3
µL dispensed: 7 from 7 intermediate

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	47.73	47.73	0.295	0.300	0.332	0.002	0.004	13:53:37	No
2	43.78	43.78	0.270	0.276	0.339	0.000	0.004	13:55:51	No
Mean:	45.76	45.76	0.283						
SD :	2.795	2.795	0.017						
%RSD:	6.11	6.11	6.11						

Element: Cu Seq. No.: 11 AS Loc.: 8 Date: 12/06/2011
Sample ID: 4
µL dispensed: 7 from 8 final

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	57.84	57.84	0.357	0.362	0.405	0.002	0.003	13:58:06	No
2	53.59	53.59	0.331	0.336	0.423	0.001	0.003	14:00:19	No
Mean:	55.71	55.71	0.344						
SD :	3.006	3.006	0.019						
%RSD:	5.40	5.40	5.40						

Element: Cu Seq. No.: 12 AS Loc.: 9 Date: 12/06/2011
Sample ID: 5 effluent
µL dispensed: 7 from 9

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	27.60	27.60	0.170	0.176	0.197	0.000	0.003	14:02:34	No
2	26.64	26.64	0.165	0.170	0.214	0.000	0.003	14:04:49	No
Mean:	27.12	27.12	0.167						
SD :	0.677	0.677	0.004						
%RSD:	2.49	2.49	2.49						

Element: Cu Seq. No.: 13 AS Loc.: 10 Date: 12/06/2011
Sample ID: 6
µL dispensed: 7 from 10 mw influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	55.18	55.18	0.341	0.346	0.391	0.002	0.003	14:07:04	No
2	54.75	54.75	0.338	0.343	0.389	0.002	0.003	14:09:17	No
Mean:	54.96	54.96	0.339						
SD :	0.304	0.304	0.002						
%RSD:	0.55	0.55	0.55						

Element: Cu Seq. No.: 14 AS Loc.: 11 Date: 12/06/2011
Sample ID: 7
µL dispensed: 7 from 11 mw primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	47.60	47.60	0.294	0.299	0.337	0.002	0.003	14:11:32	No
2	45.79	45.79	0.283	0.288	0.323	0.001	0.003	14:13:46	No
Mean:	46.70	46.70	0.288						
SD :	1.279	1.279	0.008						
%RSD:	2.74	2.74	2.74						

Element: Cu Seq. No.: 15 AS Loc.: 12 Date: 12/06/2011
Sample ID: 8
µL dispensed: 7 from 12 mw effluent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	18.50	18.50	0.114	0.119	0.154	0.000	0.003	14:16:01	No
2	17.72	17.72	0.109	0.115	0.150	0.001	0.003	14:18:15	No
Mean:	18.11	18.11	0.112						
SD :	0.548	0.548	0.003						
%RSD:	3.03	3.03	3.03						

Element: Cu Seq. No.: 16 AS Loc.: 13 Date: 12/06/2011
Sample ID: Nist1640
µL dispensed: 7 from 13

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	79.52	79.52	0.491	0.496	0.645	0.002	0.005	14:20:30	No
2	78.73	78.73	0.486	0.491	0.641	0.002	0.004	14:22:44	No
Mean:	79.13	79.13	0.489						
SD :	0.559	0.559	0.003						
%RSD:	0.71	0.71	0.71						

Method Name: dpel-Cu Element: Cu DISSOLVED
Method Description: Copper by Furnace

Date: 12/13/2011
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 60
Sample Info File: CU-12-12.SIF Results Data Set: 12-13-11-Cu Dis

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 12/13/2011
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.043	0.043	0.076	-0.001	0.003	07:08:52	No

Element: Cu Seq. No.: 2 AS Loc.: 1 Date: 12/13/2011
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.029	0.029	0.048	-0.002	0.003	07:11:30	No

Element: Cu Seq. No.: 3 AS Loc.: 1 Date: 12/13/2011
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.034	0.034	0.068	-0.001	0.002	07:14:05	No
2			0.010	0.010	0.016	-0.002	0.002	07:16:20	No
Mean:			0.022						
SD :			0.017						
%RSD:			77.30						

Auto-zero performed.

Element: Cu Seq. No.: 4 AS Loc.: 2 Date: 12/13/2011
Sample ID: 10ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.096	0.118	0.145	-0.001	0.003	07:18:35	No
2			0.083	0.106	0.132	-0.002	0.002	07:20:50	No
Mean:			0.090						
SD :			0.009						
%RSD:			9.67						

Standard number 1 applied. [10]
Correlation Coefficient: 1.0000 Slope: 0.0090

Element: Cu Seq. No.: 5 AS Loc.: 3 Date: 12/13/2011
Sample ID: 20ppb
µL dispensed: 15 from 3

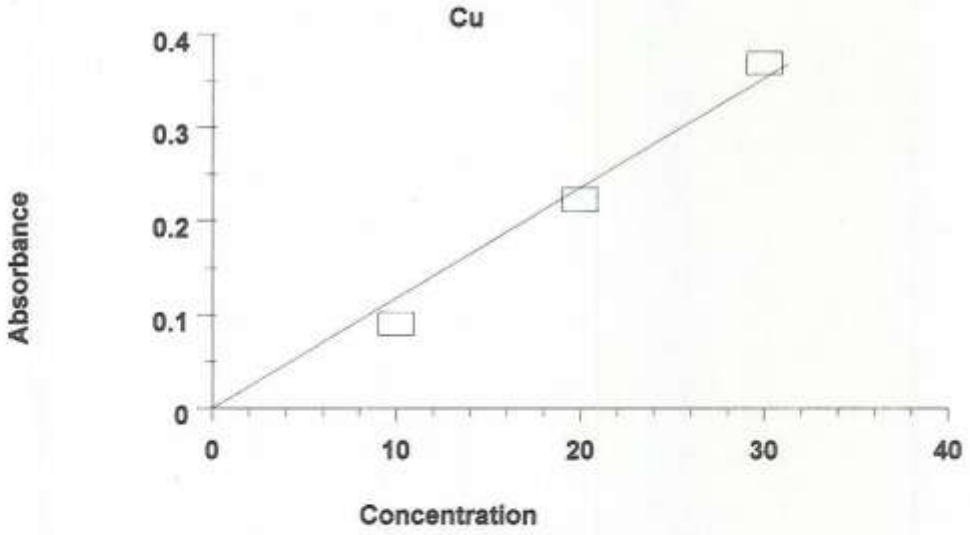
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.217	0.239	0.289	0.000	0.003	07:23:06	No
2			0.228	0.250	0.303	-0.001	0.003	07:25:21	No
Mean:			0.222						
SD :			0.008						
%RSD:			3.39						

Standard number 2 applied. [20]
Correlation Coefficient: 0.9673 Slope: 0.0108

Element: Cu Seq. No.: 6 AS Loc.: 4 Date: 12/13/2011
Sample ID: 30ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.371	0.393	0.461	0.000	0.005	07:27:36	No
2			0.367	0.389	0.450	-0.001	0.003	07:29:50	No
Mean:			0.369						
SD :			0.003						
%RSD:			0.88						

The calibration curve may not be linear.
Standard number 3 applied. [30]
Correlation Coefficient: 0.9779 Slope: 0.0118



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.017	77.297
10ppb	0.090	10	7.600	0.009	9.671
20ppb	0.222	20	18.85	0.008	3.387
30ppb	0.369	30	31.28	0.003	0.879

Correlation Coefficient: 0.97793 Slope: 0.01179

Element: Cu Seq. No.: 7 AS Loc.: 5 Date: 12/13/2011
Sample ID: 1 influent
µL dispensed: 15 from 5

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	8.482	8.482	0.100	0.122	0.142	-0.001	0.003	07:32:38	No
2	7.928	7.928	0.093	0.116	0.133	-0.001	0.002	07:34:53	No
Mean:	8.205	8.205	0.097						
SD :	0.392	0.392	0.005						
%RSD:	4.77	4.77	4.77						

Element: Cu Seq. No.: 8 AS Loc.: 6 Date: 12/13/2011
Sample ID: 2
µL dispensed: 15 from 6 primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	2.771	2.771	0.033	0.055	0.067	0.000	0.002	07:37:08	No
2	2.767	2.767	0.033	0.055	0.070	-0.001	0.003	07:39:21	No
Mean:	2.769	2.769	0.033						
SD :	0.003	0.003	0.000						
%RSD:	0.09	0.09	0.09						

Element: Cu Seq. No.: 9 AS Loc.: 7 Date: 12/13/2011
Sample ID: 3
µL dispensed: 15 from 7 intermediate

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	3.512	3.512	0.041	0.064	0.078	-0.001	0.003	07:41:36	No
2	3.356	3.356	0.040	0.062	0.076	-0.001	0.003	07:43:49	No
Mean:	3.434	3.434	0.040						
SD :	0.111	0.111	0.001						
%RSD:	3.22	3.22	3.22						

Element: Cu Seq. No.: 10 AS Loc.: 8 Date: 12/13/2011
Sample ID: 4
µL dispensed: 15 from 8 final

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	4.986	4.986	0.059	0.081	0.103	-0.001	0.003	07:46:05	No
2	4.610	4.610	0.054	0.076	0.096	-0.002	0.004	07:48:19	No
Mean:	4.798	4.798	0.057						
SD :	0.266	0.266	0.003						
%RSD:	5.55	5.55	5.55						

Element: Cu Seq. No.: 11 AS Loc.: 9 Date: 12/13/2011
Sample ID: 5
µL dispensed: 15 from 9 effluent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	4.522	4.522	0.053	0.075	0.098	-0.002	0.002	07:50:34	No
2	4.130	4.130	0.049	0.071	0.093	-0.001	0.002	07:52:49	No
Mean:	4.326	4.326	0.051						
SD :	0.277	0.277	0.003						
%RSD:	6.40	6.40	6.40						

Element: Cu Seq. No.: 12 AS Loc.: 10 Date: 12/13/2011
Sample ID: 6
µL dispensed: 15 from 10 Leominster influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	2.930	2.930	0.035	0.057	0.072	-0.002	0.002	07:55:05	No
2	3.086	3.086	0.036	0.059	0.076	-0.001	0.003	07:57:19	No
Mean:	3.008	3.008	0.035						
SD :	0.110	0.110	0.001						
%RSD:	3.66	3.66	3.66						

Element: Cu Seq. No.: 13 AS Loc.: 11 Date: 12/13/2011
Sample ID: 7
µL dispensed: 15 from 11 Leominster effluent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	1.649	1.649	0.019	0.042	0.054	-0.002	0.003	07:59:34	No
2	1.981	1.981	0.023	0.045	0.062	-0.002	0.003	08:01:48	No
Mean:	1.815	1.815	0.021						
SD :	0.235	0.235	0.003						
%RSD:	12.94	12.94	12.94						

Element: Cu Seq. No.: 14 AS Loc.: 12 Date: 12/13/2011
Sample ID: 8
µL dispensed: 15 from 12 UB influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	4.013	4.013	0.047	0.069	0.094	-0.001	0.003	08:04:03	No
2	3.796	3.796	0.045	0.067	0.088	-0.001	0.003	08:06:18	No
Mean:	3.905	3.905	0.046						
SD :	0.154	0.154	0.002						
%RSD:	3.93	3.93	3.93						

Element: Cu Seq. No.: 15 AS Loc.: 13 Date: 12/13/2011
Sample ID: 9
µL dispensed: 15 from 13 UB primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	2.953	2.953	0.035	0.057	0.080	-0.001	0.003	08:08:32	No
2	1.749	1.749	0.021	0.043	0.055	-0.002	0.002	08:10:47	No
Mean:	2.351	2.351	0.028						
SD :	0.852	0.852	0.010						
%RSD:	36.23	36.23	36.23						

Element: Cu Seq. No.: 16 AS Loc.: 14 Date: 12/13/2011
Sample ID: 10
µL dispensed: 15 from 14 UB effluent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	1.042	1.042	0.012	0.034	0.044	-0.001	0.003	08:13:03	No
2	1.487	1.487	0.018	0.040	0.052	-0.001	0.002	08:15:16	No
Mean:	1.265	1.265	0.015						
SD :	0.314	0.314	0.004						
%RSD:	24.84	24.84	24.84						

Method Name: dpel-Cu Element: Cu Digested
Method Description: Copper by Furnace

Date: 12/13/2011
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 60
Sample Info File: Untitled Results Data Set: 12-13-11 Dig

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 12/13/2011
Sample ID: Calib Blank
µL dispensed: 10 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.010	0.010	0.017	-0.002	0.002	08:34:04	No
2			0.011	0.011	0.018	-0.002	0.003	08:36:17	No
Mean:			0.011						
SD :			0.001						
%RSD:			10.04						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 12/13/2011
Sample ID: 20ppb
µL dispensed: 10 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.107	0.117	0.146	-0.002	0.002	08:38:31	No
2			0.109	0.120	0.147	-0.002	0.002	08:40:47	No
Mean:			0.108						
SD :			0.001						
%RSD:			1.38						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0054

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 12/13/2011
Sample ID: 50ppb
µL dispensed: 10 from 3

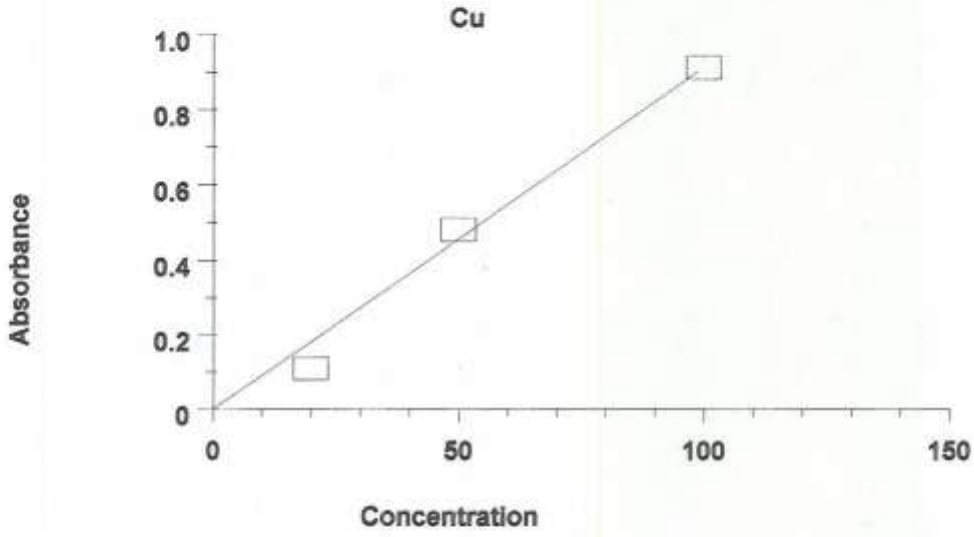
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.474	0.484	0.572	0.001	0.005	08:43:02	No
2			0.486	0.497	0.581	0.001	0.004	08:45:15	No
Mean:			0.480						
SD :			0.009						
%RSD:			1.80						

Standard number 2 applied. [50]
Correlation Coefficient: 0.9154 Slope: 0.0093

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 12/13/2011
Sample ID: 100ppb
µL dispensed: 10 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.900	0.911	1.014	0.003	0.006	08:47:30	No
2			0.922	0.932	1.027	0.002	0.004	08:49:45	No
Mean:			0.911						
SD :			0.015						
%RSD:			1.66						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9887 Slope: 0.0091



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.001	10.040
20ppb	0.108	20	11.81	0.001	1.378
50ppb	0.480	50	52.50	0.009	1.802
100ppb	0.911	100	99.65	0.015	1.658

Correlation Coefficient: 0.98869 Slope: 0.00914

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 12/13/2011
Sample ID: 1
µL dispensed: 10 from 5 influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	88.23	88.23	0.807	0.817	0.850	0.002	0.006	08:52:29	No
2	56.17	56.17	0.513	0.524	0.549	0.001	0.004	08:54:44	No
Mean:	72.20	72.20	0.660						
SD :	22.67	22.67	0.207						
%RSD:	31.40	31.40	31.40						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 12/13/2011
Sample ID: 2
µL dispensed: 10 from 6 primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	43.38	43.38	0.397	0.407	0.432	0.002	0.004	08:56:58	No
2	43.00	43.00	0.393	0.404	0.428	0.000	0.004	08:59:11	No
Mean:	43.19	43.19	0.395						
SD :	0.264	0.264	0.002						
%RSD:	0.61	0.61	0.61						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 12/13/2011
Sample ID: 3
µL dispensed: 10 from 7 intermediate

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	49.66	49.66	0.454	0.464	0.491	0.001	0.005	09:01:26	No
2	48.50	48.50	0.443	0.454	0.457	0.001	0.003	09:03:40	No
Mean:	49.08	49.08	0.449						
SD :	0.820	0.820	0.007						
%RSD:	1.67	1.67	1.67						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 12/13/2011
Sample ID: 4
µL dispensed: 10 from 8 final

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	19.45	19.45	0.178	0.188	0.208	-0.001	0.003	09:05:54	No
2	18.78	18.78	0.172	0.182	0.204	0.000	0.003	09:08:09	No
Mean:	19.12	19.12	0.175						
SD :	0.472	0.472	0.004						
%RSD:	2.47	2.47	2.47						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 12/13/2011
Sample ID: 5
µL dispensed: 10 from 9 effluent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	11.37	11.37	0.104	0.114	0.113	-0.001	0.003	09:10:24	No
2	10.89	10.89	0.100	0.110	0.125	-0.002	0.003	09:12:37	No
Mean:	11.13	11.13	0.102						
SD :	0.342	0.342	0.003						
%RSD:	3.07	3.07	3.07						

Element: Cu Seq. No.: 10 AS Loc.: 10 Date: 12/13/2011
Sample ID: 6
µL dispensed: 10 from 10 Leominster influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	24.32	24.32	0.222	0.233	0.269	-0.001	0.003	09:14:54	No
2	23.78	23.78	0.217	0.228	0.267	-0.001	0.003	09:17:07	No
Mean:	24.05	24.05	0.220						
SD :	0.385	0.385	0.004						
%RSD:	1.60	1.60	1.60						

Element: Cu Seq. No.: 11 AS Loc.: 11 Date: 12/13/2011
Sample ID: 7
µL dispensed: 10 from 11 Leominster effluent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	5.826	5.826	0.053	0.064	0.071	-0.001	0.002	09:19:21	No
2	5.025	5.025	0.046	0.056	0.064	-0.001	0.002	09:21:35	No
Mean:	5.426	5.426	0.050						
SD :	0.566	0.566	0.005						
%RSD:	10.44	10.44	10.44						

Element: Cu Seq. No.: 12 AS Loc.: 12 Date: 12/13/2011
Sample ID: 8
µL dispensed: 10 from 12 UB influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	99.82	99.82	0.913	0.923	0.901	0.004	0.006	09:23:50	No
2	100.5	100.5	0.919	0.930	0.897	0.003	0.006	09:26:04	No
Mean:	100.2	100.2	0.916						
SD :	0.512	0.512	0.005						
%RSD:	0.51	0.51	0.51						

Element: Cu Seq. No.: 13 AS Loc.: 13 Date: 12/13/2011
Sample ID: 6
µL dispensed: 10 from 13 us primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	32.31	32.31	0.295	0.306	0.297	-0.001	0.003	09:28:20	No
2	31.66	31.66	0.289	0.300	0.290	0.000	0.004	09:30:33	No
Mean:	31.99	31.99	0.292						
SD :	0.456	0.456	0.004						
%RSD:	1.42	1.42	1.42						

Element: Cu Seq. No.: 14 AS Loc.: 14 Date: 12/13/2011
Sample ID: 10
µL dispensed: 10 from 14 us effluent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	13.45	13.45	0.123	0.133	0.159	-0.001	0.003	09:32:48	No
2	13.36	13.36	0.122	0.133	0.164	-0.001	0.003	09:35:03	No
Mean:	13.41	13.41	0.123						
SD :	0.059	0.059	0.001						
%RSD:	0.44	0.44	0.44						

Method Name: dpel-Cu - Element: Cu
Method Description: Copper by Furnace Dissolved Cu

Date: 01/18/2012
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 60
Sample Info File: Untitled Results Data Set: cu mgp 1-18-12

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 01/18/2012
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.004	0.004	0.006	-0.001	0.003	07:06:17	No
2			0.005	0.005	0.007	-0.003	0.003	07:08:32	No
Mean:			0.005						
SD :			0.000						
%RSD:			8.30						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 01/18/2012
Sample ID: 10ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.073	0.077	0.096	-0.003	0.002	07:10:46	No
2			0.074	0.079	0.097	-0.002	0.002	07:13:01	No
Mean:			0.073						
SD :			0.001						
%RSD:			1.14						

Standard number 1 applied. [10]
Correlation Coefficient: 1.0000 Slope: 0.0073

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 01/18/2012
Sample ID: 20ppb
µL dispensed: 15 from 3

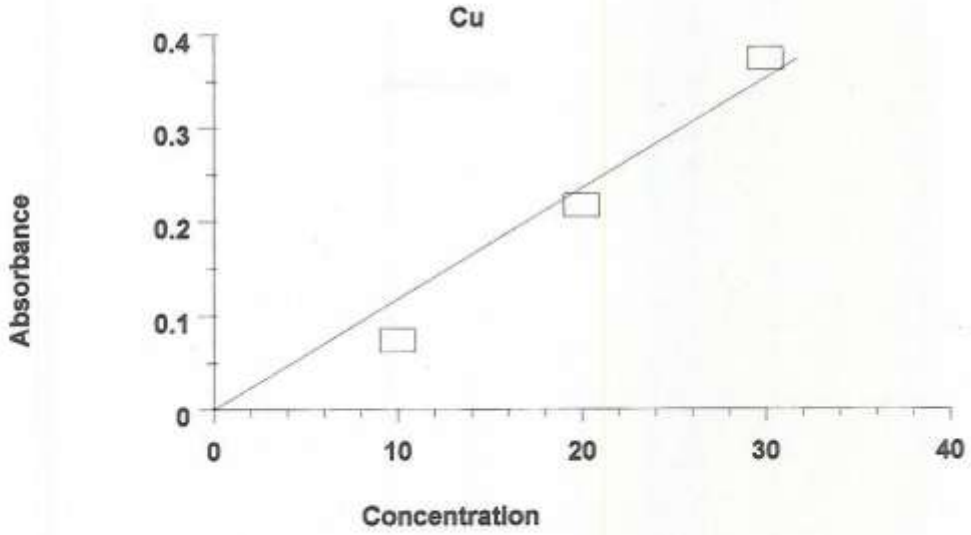
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.212	0.217	0.265	-0.001	0.003	07:15:15	No
2			0.220	0.225	0.270	-0.001	0.003	07:17:31	No
Mean:			0.216						
SD :			0.006						
%RSD:			2.68						

Standard number 2 applied. [20]
Correlation Coefficient: 0.9026 Slope: 0.0103

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 01/18/2012
Sample ID: 30ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.371	0.376	0.445	0.001	0.003	07:19:46	No
2			0.375	0.379	0.442	0.000	0.004	07:22:00	No
Mean:			0.373						
SD :			0.002						
%RSD:			0.62						

The calibration curve may not be linear.
Standard number 3 applied. [30]
Correlation Coefficient: 0.9492 Slope: 0.0118



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.000	8.302
10ppb	0.073	10	6.228	0.001	1.137
20ppb	0.216	20	18.35	0.006	2.681
30ppb	0.373	30	31.69	0.002	0.617

Correlation Coefficient: 0.94919 Slope: 0.01177

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 01/18/2012
Sample ID: (1)
µL dispensed: 15 from 5 influent

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	17.89	17.89	0.210	0.215	0.243	0.000	0.004	07:24:34	No
2	16.43	16.43	0.193	0.198	0.222	-0.001	0.003	07:26:49	No
Mean:	17.16	17.16	0.202						
SD :	1.028	1.028	0.012						
%RSD:	5.99	5.99	5.99						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 01/18/2012
Sample ID: (2)
µL dispensed: 15 from 6 primary

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	15.80	15.80	0.186	0.191	0.215	-0.002	0.003	07:29:05	No
2	15.65	15.65	0.184	0.189	0.213	-0.001	0.003	07:31:20	No
Mean:	15.72	15.72	0.185						
SD :	0.100	0.100	0.001						
%RSD:	0.64	0.64	0.64						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 01/18/2012
Sample ID: (3)
µL dispensed: 15 from 7 intermediate

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	7.254	7.254	0.085	0.090	0.099	-0.002	0.003	07:33:35	No
2	7.361	7.361	0.087	0.091	0.101	-0.001	0.002	07:35:50	No
Mean:	7.308	7.308	0.086						
SD :	0.075	0.075	0.001						
%RSD:	1.03	1.03	1.03						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 01/18/2012
Sample ID: (4)
µL dispensed: 15 from 8 final

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	8.254	8.254	0.097	0.102	0.121	0.000	0.002	07:38:05	No
2	8.162	8.162	0.096	0.101	0.122	-0.001	0.003	07:40:21	No
Mean:	8.208	8.208	0.097						
SD :	0.065	0.065	0.001						
%RSD:	0.79	0.79	0.79						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 01/18/2012
Sample ID: 5 effluent
µL dispensed: 15 from 9

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	3.053	3.053	0.036	0.041	0.046	-0.001	0.003	07:42:36	No
2	2.954	2.954	0.035	0.039	0.047	-0.001	0.003	07:44:51	No
Mean:	3.004	3.004	0.035						
SD :	0.070	0.070	0.001						
%RSD:	2.32	2.32	2.32						

DIGESTED

Element: Cu Seq. No.: 3 AS Loc.: 1 Date: 01/19/2012
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.003	0.007	0.008	-0.002	0.003	09:46:06	No
2			0.002	0.006	0.007	-0.002	0.002	09:48:20	No
Mean:			0.003						
SD :			0.001						
%RSD:			35.12						

Auto-zero performed.

Element: Cu Seq. No.: 4 AS Loc.: 2 Date: 01/19/2012
Sample ID: 20ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.190	0.196	0.237	-0.001	0.002	09:50:36	No
2			0.213	0.220	0.264	0.000	0.003	09:52:52	No
Mean:			0.202						
SD :			0.017						
%RSD:			8.20						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0101

Element: Cu Seq. No.: 5 AS Loc.: 3 Date: 01/19/2012
Sample ID: 50ppb
µL dispensed: 15 from 3

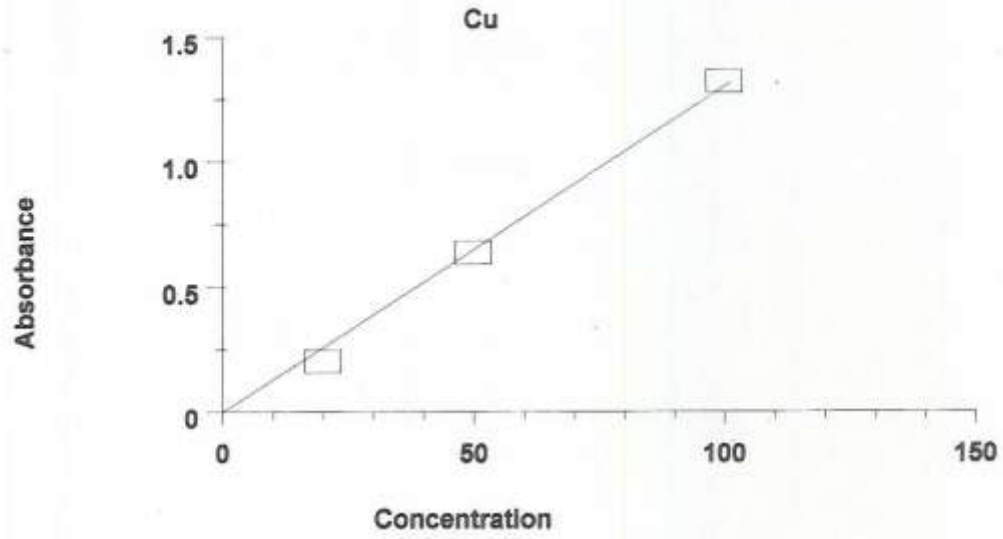
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.631	0.638	0.731	0.002	0.004	09:55:06	No
2			0.635	0.641	0.733	0.002	0.006	09:57:21	No
Mean:			0.633						
SD :			0.002						
%RSD:			0.39						

Standard number 2 applied. [50]
Correlation Coefficient: 0.9831 Slope: 0.0124

Element: Cu Seq. No.: 6 AS Loc.: 4 Date: 01/19/2012
Sample ID: 100ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			1.311	1.318	1.387	0.003	0.006	09:59:35	No
2			1.314	1.321	1.403	0.004	0.006	10:01:50	No
Mean:			1.313						
SD :			0.002						
%RSD:			0.17						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9965 Slope: 0.0130



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.001	35.124
20ppb	0.202	20	15.55	0.017	8.204
50ppb	0.633	50	48.83	0.002	0.389
100ppb	1.313	100	101.2	0.002	0.166

Correlation Coefficient: 0.99652 Slope: 0.01297

Element: Cu Seq. No.: 7 AS Loc.: 5 Date: 01/19/2012
Sample ID: 1
µL dispensed: 15 from 5

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	88.59	88.59	1.149	1.155	1.164	0.004	0.006	10:06:10	No
2	79.03	79.03	1.025	1.031	1.036	0.003	0.006	10:08:25	No
Mean:	83.81	83.81	1.087						
SD :	6.757	6.757	0.088						
%RSD:	8.06	8.06	8.06						

Element: Cu Seq. No.: 8 AS Loc.: 6 Date: 01/19/2012
Sample ID: 2
µL dispensed: 15 from 6

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	61.47	61.47	0.797	0.804	0.826	0.003	0.005	10:10:41	No
2	61.34	61.34	0.795	0.802	0.823	0.001	0.005	10:12:56	No
Mean:	61.40	61.40	0.796						
SD :	0.095	0.095	0.001						
%RSD:	0.15	0.15	0.15						

Element: Cu Seq. No.: 9 AS Loc.: 7 Date: 01/19/2012
Sample ID: 3
µL dispensed: 15 from 7

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	39.14	39.14	0.507	0.514	0.504	0.001	0.004	10:15:13	No
2	39.07	39.07	0.507	0.513	0.534	0.001	0.004	10:17:28	No
Mean:	39.10	39.10	0.507						
SD :	0.049	0.049	0.001						
%RSD:	0.13	0.13	0.13						

Element: Cu Seq. No.: 10 AS Loc.: 8 Date: 01/19/2012
Sample ID: 4
µL dispensed: 15 from 8

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	39.63	39.63	0.514	0.520	0.564	0.002	0.005	10:19:43	No
2	38.80	38.80	0.503	0.510	0.556	0.002	0.005	10:21:58	No
Mean:	39.22	39.22	0.508						
SD :	0.585	0.585	0.008						
%RSD:	1.49	1.49	1.49						

Element: Cu Seq. No.: 11 AS Loc.: 9 Date: 01/19/2012
Sample ID: 5
µL dispensed: 15 from 9

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	1.483	1.483	0.019	0.026	0.017	-0.003	0.002	10:24:14	No
2	0.847	0.847	0.011	0.017	0.010	-0.002	0.002	10:26:28	No
Mean:	1.165	1.165	0.015						
SD :	0.450	0.450	0.006						
%RSD:	38.62	38.62	38.62						

NO SAMPLE IN CUP
PAGE 6 FOR RESULT FOR #5

Element: Cu Seq. No.: 12 AS Loc.: 9 Date: 01/19/2012
Sample ID: (5)
µL dispensed: 15 from 9

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	29.11	29.11	0.377	0.384	0.420	0.001	0.004	10:28:54	No
2	33.32	33.32	0.432	0.439	0.482	0.001	0.004	10:31:09	No
Mean:	31.21	31.21	0.405						
SD :	2.978	2.978	0.039						
%RSD:	9.54	9.54	9.54						

Method Name: dpel-Cu Element: Cu
Method Description: Copper by Furnace FILTRATION

Date: 01/26/2012
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 60
Sample Info File: Untitled Results Data Set: CU MQP 1-26-12

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 01/26/2012
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.011	0.011	0.014	-0.002	0.003	08:50:59	No
2			0.011	0.011	0.015	-0.002	0.002	08:53:13	No
Mean:			0.011						
SD :			0.000						
%RSD:			1.15						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 01/26/2012
Sample ID: 20ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.165	0.177	0.212	-0.001	0.003	08:55:28	No
2			0.183	0.195	0.233	-0.001	0.003	08:57:43	No
Mean:			0.174						
SD :			0.013						
%RSD:			7.30						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0087

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 01/26/2012
Sample ID: 50ppb
µL dispensed: 15 from 3

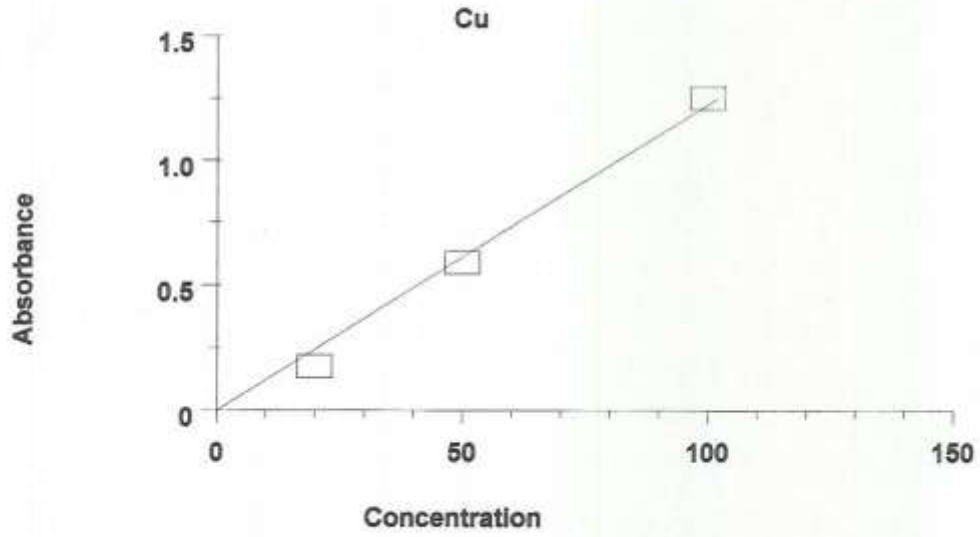
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.568	0.579	0.665	0.001	0.005	08:59:58	No
2			0.607	0.618	0.705	0.002	0.006	09:02:12	No
Mean:			0.588						
SD :			0.028						
%RSD:			4.69						

Standard number 2 applied. [50]
Correlation Coefficient: 0.9724 Slope: 0.0114

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 01/26/2012
Sample ID: 100ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			1.244	1.255	1.331	0.004	0.006	09:04:27	No
2			1.250	1.261	1.346	0.003	0.005	09:06:43	No
Mean:			1.247						
SD :			0.004						
%RSD:			0.36						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9938 Slope: 0.0123



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.000	1.146
20ppb	0.174	20	14.23	0.013	7.304
50ppb	0.588	50	47.95	0.028	4.689
100ppb	1.247	100	101.8	0.004	0.360

Correlation Coefficient: 0.99376 Slope: 0.01225

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 01/26/2012
Sample ID: (1) 1-2 mm
µL dispensed: 15 from 5

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	53.81	53.81	0.659	0.671	0.749	0.003	0.005	09:09:23	No
2	35.72	35.72	0.438	0.449	0.501	0.001	0.006	09:11:38	No
Mean:	44.77	44.77	0.548						
SD :	12.79	12.79	0.157						
%RSD:	28.58	28.58	28.58						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 01/26/2012
Sample ID: (2) 5 mm
µL dispensed: 15 from 6

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	44.57	44.57	0.546	0.557	0.623	0.001	0.005	09:13:54	No
2	44.76	44.76	0.548	0.560	0.628	0.001	0.005	09:16:08	No
Mean:	44.67	44.67	0.547						
SD :	0.136	0.136	0.002						
%RSD:	0.30	0.30	0.30						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 01/26/2012
Sample ID: (3) 10 mm
µL dispensed: 15 from 7

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	57.35	57.35	0.703	0.714	0.784	0.002	0.005	09:18:24	No
2	57.00	57.00	0.698	0.710	0.781	0.002	0.005	09:20:38	No
Mean:	57.17	57.17	0.700						
SD :	0.244	0.244	0.003						
%RSD:	0.43	0.43	0.43						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 01/26/2012
Sample ID: (4) Filter Paper
µL dispensed: 15 from 8

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	36.26	36.26	0.444	0.455	0.508	0.001	0.004	09:22:55	No
2	35.59	35.59	0.436	0.447	0.501	0.000	0.004	09:25:10	No
Mean:	35.93	35.93	0.440						
SD :	0.477	0.477	0.006						
%RSD:	1.33	1.33	1.33						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 01/26/2012
Sample ID: (6) unfiltered
µL dispensed: 15 from 9

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	20.67	20.67	0.253	0.265	0.296	-0.001	0.004	09:27:26	No
2	21.02	21.02	0.258	0.269	0.304	0.000	0.003	09:29:40	No
Mean:	20.85	20.85	0.255						
SD :	0.247	0.247	0.003						
%RSD:	1.18	1.18	1.18						

Element: Cu Seq. No.: 10 AS Loc.: 10 Date: 01/26/2012
Sample ID: (6) 0.45 µm
µL dispensed: 15 from 10

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	34.87	34.87	0.427	0.438	0.503	0.001	0.004	09:31:56	No
2	34.49	34.49	0.423	0.434	0.497	0.000	0.004	09:34:11	No
Mean:	34.68	34.68	0.425						
SD :	0.265	0.265	0.003						
%RSD:	0.76	0.76	0.76						

Method Name: dpel-Cu Element: Cu
Method Description: Copper by Furnace DIGESTED

Date: 02/01/2012
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 60
Sample Info File: Untitled Results Data Set: Cu MQP 2/1/12

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 02/01/2012
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.013	0.013	0.014	-0.003	0.002	07:38:43	No

Element: Cu Seq. No.: 2 AS Loc.: 1 Date: 02/01/2012
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.010	0.010	0.014	-0.002	0.002	07:41:16	No
2			0.008	0.008	0.014	-0.002	0.002	07:43:32	No
Mean:			0.009						
SD :			0.001						
%RSD:			14.46						

Auto-zero performed.

Element: Cu Seq. No.: 3 AS Loc.: 2 Date: 02/01/2012
Sample ID: 20ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.161	0.170	0.207	-0.001	0.002	07:45:47	No
2			0.196	0.205	0.247	0.000	0.004	07:48:02	No
Mean:			0.179						
SD :			0.025						
%RSD:			13.94						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0089

Element: Cu Seq. No.: 4 AS Loc.: 3 Date: 02/01/2012
Sample ID: 50ppb
µL dispensed: 15 from 3

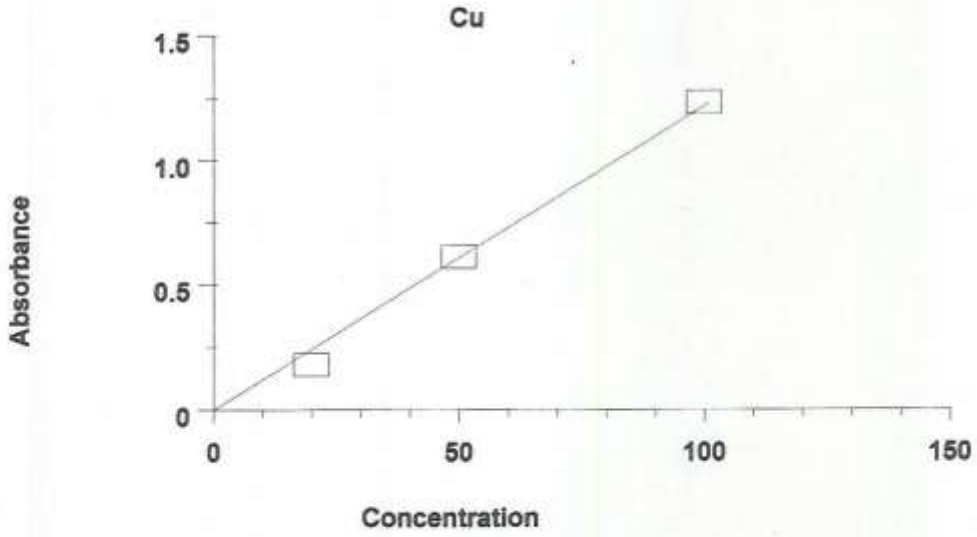
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.593	0.603	0.700	0.002	0.005	07:50:17	No
2			0.622	0.631	0.722	0.001	0.004	07:52:32	No
Mean:			0.607						
SD :			0.020						
%RSD:			3.27						

Standard number 2 applied. [50]
Correlation Coefficient: 0.9708 Slope: 0.0118

Element: Cu Seq. No.: 5 AS Loc.: 4 Date: 02/01/2012
Sample ID: 100ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			1.237	1.246	1.326	0.004	0.005	07:54:47	No
2			1.213	1.222	1.307	0.003	0.005	07:57:03	No
Mean:			1.225						
SD :			0.017						
%RSD:			1.39						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9956 Slope: 0.0122



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.001	14.458
20ppb	0.179	20	14.69	0.025	13.936
50ppb	0.607	50	49.98	0.020	3.270
100ppb	1.225	100	100.8	0.017	1.388

Correlation Coefficient: 0.99557 Slope: 0.01216

Element: Cu Seq. No.: 6 AS Loc.: 5 Date: 02/01/2012
Sample ID: 1
µL dispensed: 15 from 5

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	45.75	45.75	0.556	0.565	0.659	0.002	0.005	08:02:20	No
2	35.49	35.49	0.431	0.441	0.508	0.001	0.005	08:04:34	No
Mean:	40.62	40.62	0.494						
SD :	7.258	7.258	0.088						
%RSD:	17.87	17.87	17.87						

Element: Cu Seq. No.: 7 AS Loc.: 6 Date: 02/01/2012
Sample ID: 2
µL dispensed: 15 from 6

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	29.81	29.81	0.362	0.371	0.429	0.000	0.004	08:06:51	No
2	29.83	29.83	0.363	0.372	0.435	0.000	0.004	08:09:05	No
Mean:	29.82	29.82	0.362						
SD :	0.017	0.017	0.000						
%RSD:	0.06	0.06	0.06						

Element: Cu Seq. No.: 8 AS Loc.: 7 Date: 02/01/2012
Sample ID: 3
µL dispensed: 15 from 7

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	35.72	35.72	0.434	0.443	0.517	0.001	0.004	08:11:21	No
2	35.66	35.66	0.433	0.443	0.519	0.001	0.004	08:13:37	No
Mean:	35.69	35.69	0.434						
SD :	0.046	0.046	0.001						
%RSD:	0.13	0.13	0.13						

Element: Cu Seq. No.: 9 AS Loc.: 8 Date: 02/01/2012
Sample ID: 4
µL dispensed: 15 from 8

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	32.55	32.55	0.396	0.405	0.466	0.000	0.004	08:15:53	No
2	31.91	31.91	0.388	0.397	0.460	0.001	0.004	08:18:09	No
Mean:	32.23	32.23	0.392						
SD :	0.456	0.456	0.006						
%RSD:	1.41	1.41	1.41						

Element: Cu Seq. No.: 10 AS Loc.: 9 Date: 02/01/2012
Sample ID: 5
µL dispensed: 15 from 9

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	32.14	32.14	0.391	0.400	0.474	0.001	0.004	08:20:23	No
2	31.69	31.69	0.385	0.394	0.469	0.001	0.004	08:22:37	No
Mean:	31.92	31.92	0.388						
SD :	0.322	0.322	0.004						
%RSD:	1.01	1.01	1.01						

Method Name: dpel-Cu Element: Cu DIGESTED
Method Description: Copper by Furnace

Date: 02/07/2012
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 60
Sample Info File: Untitled Results Data Set: 2-7-12 Dig

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 02/07/2012
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			-0.004	0.005	0.006	-0.002	0.002	07:14:12	No
2			-0.004	0.005	0.005	-0.002	0.002	07:16:27	No
Mean:			-0.004						
SD :			0.000						
%RSD:			4.93						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 02/07/2012
Sample ID: 30ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.261	0.266	0.324	-0.001	0.003	07:18:41	No
2			0.291	0.296	0.356	0.000	0.004	07:20:56	No
Mean:			0.276						
SD :			0.021						
%RSD:			7.74						

Standard number 1 applied. [30]
Correlation Coefficient: 1.0000 Slope: 0.0092

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 02/07/2012
Sample ID: 50ppb
µL dispensed: 15 from 3

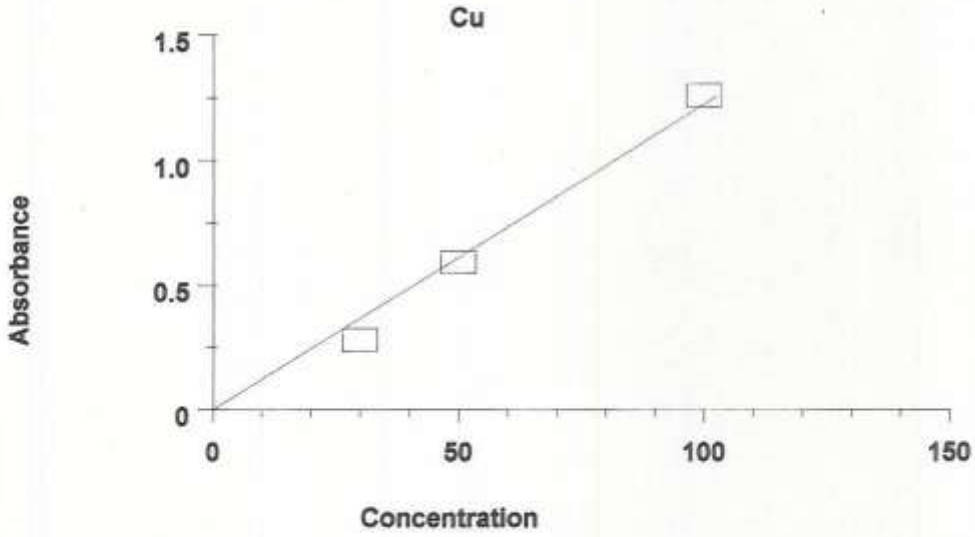
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.580	0.585	0.680	0.001	0.004	07:23:12	No
2			0.597	0.601	0.698	0.002	0.005	07:25:27	No
Mean:			0.588						
SD :			0.012						
%RSD:			2.02						

Standard number 2 applied. [50]
Correlation Coefficient: 0.9082 Slope: 0.0112

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 02/07/2012
Sample ID: 100ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			1.268	1.273	1.360	0.004	0.006	07:27:42	No
2			1.241	1.246	1.343	0.004	0.006	07:29:56	No
Mean:			1.255						
SD :			0.019						
%RSD:			1.55						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9873 Slope: 0.0122



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.000	4.928
30ppb	0.276	30	22.56	0.021	7.738
50ppb	0.588	50	48.08	0.012	2.015
100ppb	1.255	100	102.5	0.019	1.548

Correlation Coefficient: 0.98732 Slope: 0.01223

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 02/07/2012
Sample ID: 1
µL dispensed: 15 from 5

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	56.64	56.64	0.693	0.698	0.746	0.002	0.004	07:38:08	No
2	38.63	38.63	0.473	0.478	0.511	0.001	0.004	07:40:22	No
Mean:	47.64	47.64	0.583						
SD :	12.74	12.74	0.156						
%RSD:	26.74	26.74	26.74						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 02/07/2012
Sample ID: 2
µL dispensed: 15 from 6

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	50.89	50.89	0.623	0.628	0.671	0.002	0.004	07:42:36	No
2	51.88	51.88	0.635	0.640	0.682	0.001	0.004	07:44:51	No
Mean:	51.39	51.39	0.629						
SD :	0.696	0.696	0.009						
%RSD:	1.35	1.35	1.35						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 02/07/2012
Sample ID: 3
µL dispensed: 15 from 7

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	31.69	31.69	0.388	0.393	0.422	0.001	0.004	07:47:07	No
2	31.12	31.12	0.381	0.386	0.418	0.001	0.004	07:49:21	No
Mean:	31.40	31.40	0.384						
SD :	0.401	0.401	0.005						
%RSD:	1.28	1.28	1.28						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 02/07/2012
Sample ID: 4
µL dispensed: 15 from 8

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	29.89	29.89	0.366	0.371	0.403	0.001	0.005	07:51:37	No
2	29.65	29.65	0.363	0.368	0.401	0.001	0.004	07:53:52	No
Mean:	29.77	29.77	0.364						
SD :	0.166	0.166	0.002						
%RSD:	0.56	0.56	0.56						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 02/07/2012
Sample ID: 5
µL dispensed: 15 from 9

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	19.71	19.71	0.241	0.246	0.281	0.000	0.003	07:56:08	No
2	19.41	19.41	0.237	0.242	0.283	-0.001	0.003	07:58:23	No
Mean:	19.56	19.56	0.239						
SD :	0.212	0.212	0.003						
%RSD:	1.08	1.08	1.08						

Element: Cu Seq. No.: 10 AS Loc.: 10 Date: 02/07/2012
Sample ID: 6
µL dispensed: 15 from 10

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	37.91	37.91	0.464	0.469	0.547	0.001	0.005	08:00:38	No
2	38.24	38.24	0.468	0.473	0.550	0.001	0.004	08:02:52	No
Mean:	38.08	38.08	0.466						
SD :	0.233	0.233	0.003						
%RSD:	0.61	0.61	0.61						

Element: Cu Seq. No.: 11 AS Loc.: 11 Date: 02/07/2012
Sample ID: 7
µL dispensed: 15 from 11

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	20.31	20.31	0.248	0.253	0.294	-0.001	0.004	08:05:08	No
2	19.72	19.72	0.241	0.246	0.282	0.001	0.003	08:07:22	No
Mean:	20.01	20.01	0.245						
SD :	0.421	0.421	0.005						
%RSD:	2.10	2.10	2.10						

Element: Cu Seq. No.: 12 AS Loc.: 12 Date: 02/07/2012
Sample ID: 8
µL dispensed: 15 from 12

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	22.95	22.95	0.281	0.286	0.334	-0.001	0.004	08:09:39	No
2	22.24	22.24	0.272	0.277	0.327	0.000	0.003	08:11:53	No
Mean:	22.59	22.59	0.276						
SD :	0.506	0.506	0.006						
%RSD:	2.24	2.24	2.24						

Element: Cu Seq. No.: 13 AS Loc.: 13 Date: 02/07/2012
Sample ID: 9
µL dispensed: 15 from 13

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	16.28	16.28	0.199	0.204	0.241	-0.001	0.003	08:14:09	No
2	16.52	16.52	0.202	0.207	0.245	-0.001	0.003	08:16:23	No
Mean:	16.40	16.40	0.201						
SD :	0.170	0.170	0.002						
%RSD:	1.03	1.03	1.03						

Element: Cu Seq. No.: 14 AS Loc.: 14 Date: 02/07/2012
Sample ID: 10
µL dispensed: 15 from 14

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	19.46	19.46	0.238	0.243	0.291	-0.001	0.003	08:18:39	No
2	19.25	19.25	0.236	0.240	0.289	0.001	0.003	08:20:55	No
Mean:	19.36	19.36	0.237						
SD :	0.148	0.148	0.002						
%RSD:	0.77	0.77	0.77						

Method Name: dpel-Cu Element: Cu DISSOLVED
Method Description: Copper by Furnace

Date: 02/07/2012
Technique: Furnace Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 60
Sample Info File: Untitled Results Data Set: Cu MQP 2-7-12

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 02/07/2012
Sample ID: Calib Blank
µL dispensed: 20 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.010	0.010	0.010	-0.002	0.003	06:17:56	No
2			0.007	0.007	0.010	-0.001	0.003	06:20:11	No
Mean:			0.009						
SD :			0.002						
%RSD:			21.59						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 02/07/2012
Sample ID: 10ppb
µL dispensed: 20 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.107	0.115	0.141	-0.001	0.002	06:22:27	No
2			0.117	0.126	0.154	-0.002	0.003	06:24:42	No
Mean:			0.112						
SD :			0.007						
%RSD:			6.49						

Standard number 1 applied. [10]
Correlation Coefficient: 1.0000 Slope: 0.0112

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 02/07/2012
Sample ID: 30ppb
µL dispensed: 20 from 3

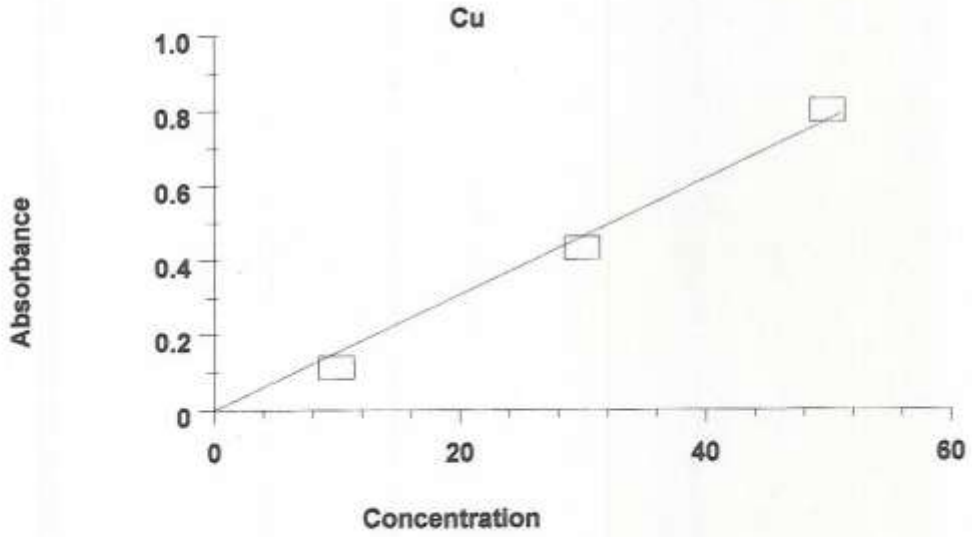
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.412	0.421	0.496	0.002	0.004	06:26:58	No
2			0.450	0.459	0.535	0.001	0.004	06:29:12	No
Mean:			0.431						
SD :			0.027						
%RSD:			6.24						

Standard number 2 applied. [30]
Correlation Coefficient: 0.9885 Slope: 0.0141

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 02/07/2012
Sample ID: 50ppb
µL dispensed: 20 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.790	0.799	0.894	0.002	0.006	06:31:27	No
2			0.803	0.811	0.901	0.002	0.004	06:33:42	No
Mean:			0.796						
SD :			0.009						
%RSD:			1.10						

The calibration curve may not be linear.
Standard number 3 applied. [50]
Correlation Coefficient: 0.9910 Slope: 0.0155



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.002	21.595
10ppb	0.112	10	7.246	0.007	6.490
30ppb	0.431	30	27.89	0.027	6.244
50ppb	0.796	50	51.53	0.009	1.101

Correlation Coefficient: 0.99097 Slope: 0.01545

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 02/07/2012
Sample ID: 1
µL dispensed: 20 from 5

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	5.673	5.673	0.088	0.096	0.101	-0.001	0.003	06:36:10	No
2	4.606	4.606	0.071	0.080	0.084	0.000	0.004	06:38:26	No
Mean:	5.140	5.140	0.079						
SD :	0.754	0.754	0.012						
%RSD:	14.67	14.67	14.67						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 02/07/2012
Sample ID: 2
µL dispensed: 20 from 6

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	8.638	8.638	0.133	0.142	0.163	0.000	0.003	06:40:42	No
2	8.178	8.178	0.126	0.135	0.156	0.000	0.003	06:42:56	No
Mean:	8.408	8.408	0.130						
SD :	0.325	0.325	0.005						
%RSD:	3.87	3.87	3.87						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 02/07/2012
Sample ID: 3
µL dispensed: 20 from 7

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	2.628	2.628	0.041	0.049	0.053	-0.001	0.002	06:45:12	No
2	2.356	2.356	0.036	0.045	0.050	-0.002	0.003	06:47:27	No
Mean:	2.492	2.492	0.039						
SD :	0.192	0.192	0.003						
%RSD:	7.72	7.72	7.72						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 02/07/2012
Sample ID: 4
µL dispensed: 20 from 8

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	3.276	3.276	0.051	0.059	0.067	-0.002	0.002	06:49:44	No
2	3.062	3.062	0.047	0.056	0.065	-0.001	0.003	06:51:59	No
Mean:	3.169	3.169	0.049						
SD :	0.151	0.151	0.002						
%RSD:	4.77	4.77	4.77						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 02/07/2012
Sample ID: 5
µL dispensed: 20 from 9

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	2.733	2.733	0.042	0.051	0.060	-0.002	0.002	06:54:15	No
2	2.241	2.241	0.035	0.043	0.051	-0.001	0.003	06:56:30	No
Mean:	2.487	2.487	0.038						
SD :	0.348	0.348	0.005						
%RSD:	13.99	13.99	13.99						

Element: Cu Seq. No.: 10 AS Loc.: 10 Date: 02/07/2012
Sample ID: 6
µL dispensed: 20 from 10

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	2.859	2.859	0.044	0.053	0.062	-0.001	0.003	06:58:47	No
2	2.797	2.797	0.043	0.052	0.061	-0.002	0.002	07:01:02	No
Mean:	2.828	2.828	0.044						
SD :	0.044	0.044	0.001						
%RSD:	1.55	1.55	1.55						

Element: Cu Seq. No.: 11 AS Loc.: 11 Date: 02/07/2012
Sample ID: 7
µL dispensed: 20 from 11

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	3.117	3.117	0.048	0.057	0.067	-0.001	0.003	07:03:17	No
2	3.035	3.035	0.047	0.056	0.065	-0.001	0.002	07:05:32	No
Mean:	3.076	3.076	0.048						
SD :	0.057	0.057	0.001						
%RSD:	1.87	1.87	1.87						

Method Name: dpel-cu Element: Cu 10 ppm Precipitation
Method Description: copper by flame

Date: 02/29/2012
Technique: Flame Calibration Equation: Zero Intercept: Linear
Wavelength: 324.8 nm Slit Width: 0.70 nm
Lamp Current: 13 Energy: 66
Sample Info File: Untitled Results Data Set:

Element: Cu Seq. No.: 1 AS Loc.: --- Date: 02/29/2012
Sample ID: Calib Blank

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.029	05:40:24
2			0.029	05:40:32
Mean:			0.029	
SD :			0.000	
%RSD:			0.04	

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: --- Date: 02/29/2012
Sample ID: Calib Blank

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.000	05:40:42
2			0.000	05:40:50
Mean:			0.000	
SD :			0.000	
%RSD:			42.85	

Auto-zero performed.

Element: Cu Seq. No.: 3 AS Loc.: --- Date: 02/29/2012
Sample ID: 1ppm

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.044	05:41:06
2			0.044	05:41:14
Mean:			0.044	
SD :			0.000	
%RSD:			0.10	

Standard number 1 applied. [1.0]
Correlation Coefficient: 1.0000 Slope: 0.0442

Element: Cu Seq. No.: 4 AS Loc.: --- Date: 02/29/2012
Sample ID: 5ppm

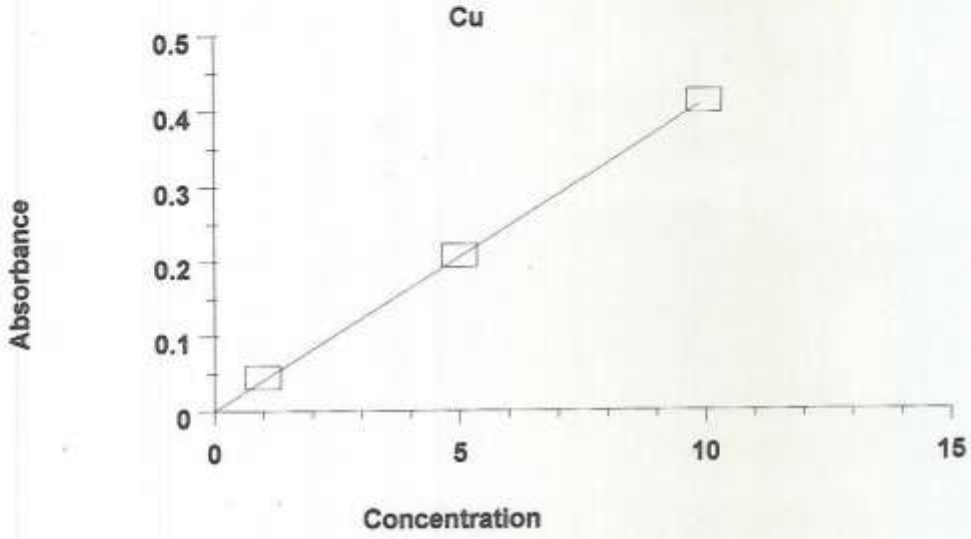
Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.207	05:41:40
2			0.207	05:41:49
Mean:			0.207	
SD :			0.000	
%RSD:			0.01	

Standard number 2 applied. [5.0]
Correlation Coefficient: 0.9997 Slope: 0.0415

Element: Cu Seq. No.: 5 AS Loc.: --- Date: 02/29/2012
Sample ID: 10ppm

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1			0.411	05:42:11
2			0.410	05:42:20
Mean:			0.410	
SD :			0.001	
%RSD:			0.22	

Standard number 3 applied. [10]
Correlation Coefficient: 0.9999 Slope: 0.0411



Calibration data for Cu

Standard ID	Mean Signal (Absorbance)	Entered Concentration (ppm)	Calculated Concentration (ppm)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.000	42.845
1ppm	0.044	1.0	1.075	0.000	0.101
5ppm	0.207	5.0	5.030	0.000	0.014
10ppm	0.410	10	9.977	0.001	0.217

Correlation Coefficient: 0.99991 Slope: 0.04113

Element: Cu Seq. No.: 6 AS Loc.: --- Date: 02/29/2012
Sample ID: 10ppm Degested Precip.

Repl #	SampleConc ppm	StndConc ppm	BlnkCorr Signal	Time
1	8.861	8.861	0.364	05:42:46
2	8.852	8.852	0.364	05:42:54
Mean:	8.856	8.856	0.364	
SD :	0.007	0.007	0.000	
%RSD:	0.07	0.07	0.07	

Sample Information File Untitled

Description	:
Batch ID	:
Volume Units	: mL
Weight Units	:
Analyst	:
Sample Volume	: 50.000
Nominal Weight	: 1.000000

AS Loc	Sample ID	Sample Weight	Sample Units	User Dilution	Remarks
0	10ppm Degested Precip.		ppm (Wt/Vol		

Method Name: dpel-Cu Element: Cu
Method Description: Copper by Furnace

Date: 04/04/2012
Technique: Furnace
Wavelength: 324.8 nm
Lamp Current: 15
Sample Info File: Untitled

Calibration Equation: Zero Intercept: Linear
Slit Width: 0.70 nm
Energy: 62
Results Data Set:

Element: Cu Seq. No.: 1 AS Loc.: 1 Date: 04/04/2012
Sample ID: Calib Blank
µL dispensed: 15 from 1

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.006	0.006	0.008	-0.002	0.002	07:21:29	No
2			0.004	0.004	0.007	-0.002	0.003	07:23:43	No
Mean:			0.005						
SD :			0.001						
%RSD:			20.70						

Auto-zero performed.

Element: Cu Seq. No.: 2 AS Loc.: 2 Date: 04/04/2012
Sample ID: 20ppb
µL dispensed: 15 from 2

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.154	0.159	0.196	-0.001	0.002	07:25:59	No
2			0.170	0.175	0.212	-0.001	0.002	07:28:13	No
Mean:			0.162						
SD :			0.011						
%RSD:			7.09						

Standard number 1 applied. [20]
Correlation Coefficient: 1.0000 Slope: 0.0081

Element: Cu Seq. No.: 3 AS Loc.: 3 Date: 04/04/2012
Sample ID: 50ppb
µL dispensed: 15 from 3

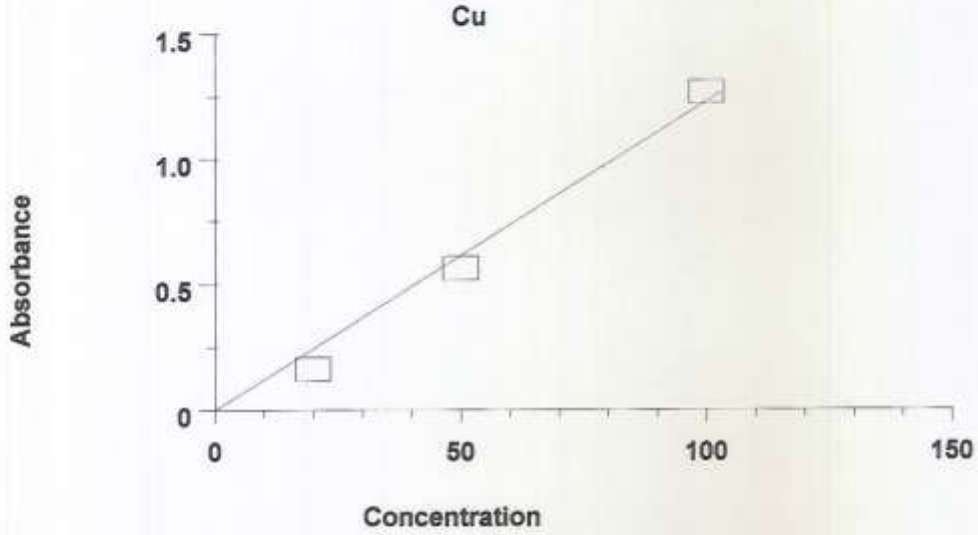
Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			0.550	0.555	0.640	0.001	0.004	07:30:28	No
2			0.571	0.576	0.663	0.002	0.004	07:32:42	No
Mean:			0.560						
SD :			0.014						
%RSD:			2.56						

Standard number 2 applied. [50]
Correlation Coefficient: 0.9680 Slope: 0.0109

Element: Cu Seq. No.: 4 AS Loc.: 4 Date: 04/04/2012
Sample ID: 100ppb
µL dispensed: 15 from 4

Repl #	SampleConc µg/L	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1			1.270	1.275	1.326	0.004	0.007	07:34:57	No
2			1.256	1.261	1.330	0.004	0.006	07:37:11	No
Mean:			1.263						
SD :			0.010						
%RSD:			0.75						

The calibration curve may not be linear.
Standard number 3 applied. [100]
Correlation Coefficient: 0.9887 Slope: 0.0123



Calibration data for Cu

Standard ID	Mean Signal (Pk Area)	Entered Concentration (µg/L)	Calculated Concentration (µg/L)	Standard Deviation	%RSD
Calib Blank	0.000	----	0.000	0.001	20.701
20ppb	0.162	20	13.20	0.011	7.087
50ppb	0.560	50	45.62	0.014	2.555
100ppb	1.263	100	102.8	0.010	0.753

Correlation Coefficient: 0.98870 Slope: 0.01228

Element: Cu Seq. No.: 5 AS Loc.: 5 Date: 04/04/2012
Sample ID: 1 4-2-12 - ~~Blank~~ Final Clarifier
µL dispensed: 15 from 5

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	5.967	5.967	0.073	0.078	0.077	-0.001	0.002	07:40:36	No
2	4.664	4.664	0.057	0.062	0.063	-0.001	0.002	07:42:50	No
Mean:	5.316	5.316	0.065						
SD :	0.921	0.921	0.011						
%RSD:	17.33	17.33	17.33						

Element: Cu Seq. No.: 6 AS Loc.: 6 Date: 04/04/2012
Sample ID: 2 4-2-12 - Precipitate
µL dispensed: 15 from 6

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	8.348	8.348	0.103	0.108	0.124	0.000	0.003	07:45:06	No
2	7.941	7.941	0.098	0.103	0.118	-0.001	0.002	07:47:19	No
Mean:	8.144	8.144	0.100						
SD :	0.287	0.287	0.004						
%RSD:	3.53	3.53	3.53						

Element: Cu Seq. No.: 7 AS Loc.: 7 Date: 04/04/2012
Sample ID: 3 4-2-12 - Filtered Precipitate
µL dispensed: 15 from 7

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	7.646	7.646	0.094	0.099	0.113	-0.002	0.002	07:49:35	No
2	7.399	7.399	0.091	0.096	0.112	-0.001	0.003	07:51:50	No
Mean:	7.522	7.522	0.092						
SD :	0.175	0.175	0.002						
%RSD:	2.33	2.33	2.33						

Element: Cu Seq. No.: 8 AS Loc.: 8 Date: 04/04/2012
Sample ID: 4 -4-2-12 - Sand Filter influent
µL dispensed: 15 from 8

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	3.240	3.240	0.040	0.045	0.049	-0.002	0.002	07:54:05	No
2	3.018	3.018	0.037	0.042	0.049	-0.002	0.003	07:56:19	No
Mean:	3.129	3.129	0.038						
SD :	0.157	0.157	0.002						
%RSD:	5.01	5.01	5.01						

Element: Cu Seq. No.: 9 AS Loc.: 9 Date: 04/04/2012
Sample ID: 5 4-2-12 - Sand Filter Effluent
µL dispensed: 15 from 9

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	5.547	5.547	0.068	0.073	0.091	-0.002	0.002	07:58:35	No
2	5.421	5.421	0.067	0.072	0.086	-0.002	0.002	08:00:50	No
Mean:	5.484	5.484	0.067						
SD :	0.089	0.089	0.001						
%RSD:	1.62	1.62	1.62						

Element: Cu Seq. No.: 10 AS Loc.: 10 Date: 04/04/2012
Sample ID: 1-Digested - Total Final Clarifier
µL dispensed: 15 from 10

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	26.25	26.25	0.322	0.328	0.386	0.000	0.003	08:03:06	No
2	21.39	21.39	0.263	0.268	0.314	0.001	0.003	08:05:21	No
Mean:	23.82	23.82	0.293						
SD :	3.438	3.438	0.042						
%RSD:	14.44	14.44	14.44						

Element: Cu Seq. No.: 11 AS Loc.: 11 Date: 04/04/2012
Sample ID: 2- Digested - Sand Filter influent
µL dispensed: 15 from 11

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	23.66	23.66	0.291	0.296	0.355	0.001	0.003	08:07:37	No
2	24.54	24.54	0.301	0.307	0.364	0.000	0.003	08:09:51	No
Mean:	24.10	24.10	0.296						
SD :	0.620	0.620	0.008						
%RSD:	2.57	2.57	2.57						

Element: Cu Seq. No.: 12 AS Loc.: 12 Date: 04/04/2012
Sample ID: 3 Digested - Sand Filter effluent
µL dispensed: 15 from 12

Repl #	SampleConc ppb	StndConc µg/L	BlnkCorr Signal	Peak Area	Peak Height	Bkgnd Area	Bkgnd Height	Time	Peak Stored
1	24.43	24.43	0.300	0.305	0.412	0.000	0.003	08:12:07	No
2	23.77	23.77	0.292	0.297	0.424	0.000	0.003	08:14:22	No
Mean:	24.10	24.10	0.296						
SD :	0.470	0.470	0.006						
%RSD:	1.95	1.95	1.95						